CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 36 San Francisco, July, 1950 Number 3

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VOLUME 36 ISSUED JULY 10, 1950 No. 3

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CALIFORNIA ANGLING CATCH RECORDS FROM POSTAL CARD SURVEYS: 1936-1948; WITH AN EVALUATION OF POSTAL CARD NONRESPONSE *

By A. J. Calhoun †
Bureau of Fish Conservation
California Division of Fish and Game

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INTRODUCTION

Valuable estimates of numbers of anglers fishing in California each year as well as the number of fish they catch are provided by special Division of Fish and Game surveys. These angling inventories enable California's fisheries administrators to evaluate the results of their efforts to improve fishing. They have also made it possible to follow the explosive increase in angling pressure which has taken place since the war. These surveys have the additional important function of providing reliable information about the striped bass fishery as a whole. Striped bass are harvested over an extensive area throughout the year by several hundred thousand anglers, and it is impractical to obtain complete records by means of creel checks or other field methods.

In making these state-wide angling surveys, return postal cards like the one shown in Figure 53 are mailed to a random sample of the anglers

* Submitted for publication April, 1950.
† Figures were drawn by Miss Margaret Chadwick. Charles Paya assisted with calculations.

PLEASE HELP THE CALIFORNIA DIVISION OF FISH AND GAME IN ITS EFFORTS TO IMPROVE FISHING BY FILLING OUT AND MAILING THIS CARD

DID YOU CATCH ANY FISH IN 1948? *(Please answer* YES OR NO) . . . . . .

HOW MANY DAYS DID YOU GO FISHING IN 1948? . . . . . .

Please list below the number of each kind of fish you caught, and the counties where you caught them
(IF YOU DO NOT KNOW EXACTLY, GIVE YOUR BEST ESTIMATE)

CODE NO.	SPECIES	COUNTY OF CATCH	NUMBER	COUNTY OF CATCH	NUMBER	COUNTY OF CATCH	NUMBER
1	SALMON						
2	ALL TROUT / INCLUDING STEELHEAD						
3	BLACK BASS						
4	CRAPPIE						
5	SUNFISH (FRESH WATER PERCH)						
6	STRIPED BASS						
7	CATFISH						
8	BARRACUDA						

HOW MANY DAYS DID YOU FISH FOR TROUT IN 1948? . . . . . .

HOW MANY DAYS DID YOU FISH FOR STRIPED BASS IN 1948? . . . . . .

REPLY CARD
THIS SIDE OF CARD IS FOR ADDRESS

California Division of Fish and Game

Department of Natural Resources

Ferry Building

Fish Conservation

San Francisco, California

THIS SIDE OF CARD IS FOR ADDRESS

Will You Help Improve Fishing in California?

In order to find out whether our efforts to provide better fishing are bringing results we need to know how many fish are caught each year in California. No one can tell us this as well as the fishermen.

We are therefore asking a selected number of California anglers to tell us what they catch. You have been chosen to take part in this test. Will you help? All we ask you to do is to:

PLEASE WRITE ON THE RETURN CARD your best estimate of the number of each kind of fish you caught last year and the counties where you caught them. Also please give us your best estimates in answer to questions about number of days fished.

IF YOU CAUGHT NO FISH OF ANY KIND, PLEASE SAY SO.

You do not need to sign the card; this is not a personal check-up. But please do send us the record of your catch, and thus do your bit for better fishing.

CALIFORNIA DIVISION OF FISH AND GAME

FIGURE 53. Return postal card used in the 1948 angling survey.

licensed in California during a calendar year.* About one-third of the recipients respond, with great regularity. Such a return is large enough to show major trends in numbers of fish caught and numbers of fishermen, because survey methods are standardized. The trends obtained undoubtedly parallel the actual changes which are taking place. On the other hand, there has always been much uncertainty about the numerical catch estimates, one reason being that it seemed improbable that individuals who returned questionnaires were representative of the general angling population. This matter was given special attention in 1948. A special personal interview survey was made that year to determine the influence of nonresponse upon estimates of various kinds, with rather surprising results. In general, the individuals who returned cards actually were found to be highly representative of the angling public as a whole. No important warping of mean catches, total catches, numbers of anglers or trout angler migrations resulted from postal card nonresponse, which is clearly not an important source of error in these estimates. It is therefore now possible to place increased confidence in them.

This report has a double purpose. The whole series of California angling catch surveys from 1936 to 1948, inclusive, is summarized in Part I. The special 1948 study of nonresponse is discussed in Part II. A later report by H. Hjersman will cover a parallel personal interview survey of 1948 hunting in California, which had essentially similar results.

The matter of nonresponse in these California surveys has been settled for the present, but the partner question of the validity of the individual angler reports remains to plague us. This problem is also discussed in Part II, in the light of the 1948 personal interview survey.

PART I—CALIFORNIA ANGLING CATCH RECORDS FROM STATE-WIDE POSTAL CARD SURVEYS

This program has had an interesting history. It originated from a desire on the part of California fish and game administrators for reasonably accurate estimates of yearly angling catches. Brian Curtis conducted the surveys for the years up to and including 1944. The author analyzed the returns from the 1944 survey and has been responsible for the program since then.

Any data in this article for surveys prior to 1944 have been extracted from unpublished reports by Curtis. Similar hunting surveys have been conducted independently from time to time (Hunter and Fry, 1940, 1941).

In the early years of these surveys, from 1935 to and including 1939, all individuals who obtained a California angling license were asked at the time of purchase to fill in a detailed questionnaire about their fishing success during the previous year. Roughly a third complied. At the end of the year the reports were collected from the license agents throughout California and the catches were then machine-tabulated to derive state-wide angling catch estimates.

This license stub method had certain serious disadvantages. The catch estimates were not usually obtained for about two years, because

* Anglers too young to require a license do not enter the sample. The minimum age was 18 until 1947 and 16 subsequently.

one year's catch was not reported until the following year, and questionnaires did not become available for tabulation until another full year had passed. Moreover, anglers who purchased their license late in the year had a long time to forget what they caught the year before. Further drawbacks stemmed from the unnecessarily large size of the sample, which caused considerable wasted effort and bothered more anglers with questionnaires than was necessary.

There were other disadvantages (Hunter & Fry, 1940), but those noted above will explain why a new procedure was tried out in 1939. Mailed questionnaires similar to those still in use, shown in Figure 53, were sent to a 10 percent random sample of all 1939 angling licensees. The usual license stub survey of 1939 angling was also made, so that any important differences in the results obtained by the two methods could be evaluated. A careful comparison by Curtis of the results of the paired surveys showed them to be comparable, for all practical purposes.

A brief resume of the whole series of angling surveys will be found in Table 1. There has been a gradual decrease over the years in the proportion of all anglers receiving questionnaires, largely because the total number of licensees has increased greatly, and it has become necessary to limit the size of the total sample because of the time and expense involved in processing the returns.

TABLE 1

Resume of California State-Wide Angling Catch Surveys

Year	Type of survey	Number of licensed anglers	Questionnaire recipients		Usable returns	
			Number	Percent of all licensees	Number	Percent of all recipients
1935*	License stub	223,098	All	100	87,103	38.9
1936	License stub	298,736	All	100	76,520	25.6
1937	License stub	312,969	All	100	90,481	28.9
1938	License stub	346,661	All	100	104,982	30.3
1939	License stub	366,452	All	100	109,701	30.0
1939	Mailed questionnaire		32,224	8.8	9,609	29.8
1940	None	388,472	None			
1941	Postal card	453,159	39,738	8.8	13,569	34.1
1942	Postal card	433,431	39,306	9.1	11,552	29.4
1943	Postal card	445,416	41,610	9.4	12,899	31.0
1944	Postal card†	436,940	9,318	2.1	2,761	29.6
1945	None	554,027	None			
1946	Postal card	766,753	29,862	3.9	8,874	29.7
1947	None	884,772	None			
1948	Postal card	‡960,027	18,070	1.9	5,751	31.8
1948	Interview		1,250	0.13	1,250	100.0

* The 1935 survey has been omitted from subsequent discussions because it was unsatisfactory in a number of respects.
† Limited to striped bass and based only on individuals purchasing licenses in nine central California counties.
‡ Not the final figure.

PRINCIPAL CALIFORNIA ANGLING TRENDS

Great changes have occurred in California angling in recent years. Perhaps the most important trend has been a continuing increase in the number of anglers. Total angling license sales doubled between 1935 and 1941, and then promptly redoubled between 1941 and 1948. These figures are shown in the third column of Table 1.

Angling license sales have been translated into terms of total fishing days in Table 2 and Figure 54.* The trend is continuously upward

* This and all other trends have been drawn in "by eye," unless otherwise noted.

TABLE 2

Total Angling Pressure in California, 1935-1948

Year	Total license sales	Average fishing days per angler	Total fishing days
1935	223,098	No data	*3,120,000
1938	346,661	No data	*4,850,000
1941	453,159	14.2	6,440,000
1942	433,431	14.3	6,180,000
1943	445,416	12.9	5,750,000
1946	766,753	13.5	10,350,000
1948	†960,027	15.4	14,700,000

* Fourteen fishing days per angler used in estimating this.
† Not the final figure.

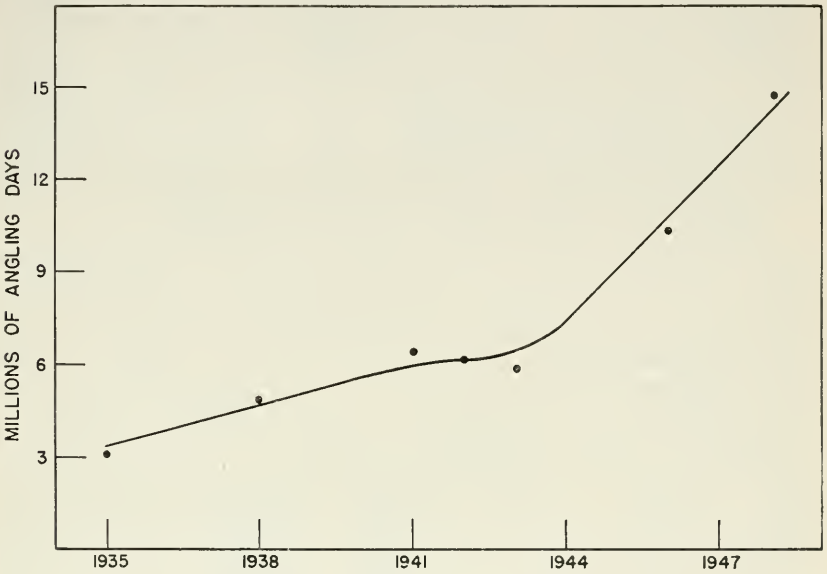

FIGURE 54. Total number of California angling days.

except for a brief levelling-off during the war. There has been about a five-fold increase in total angling pressure in California since 1935. Only a small part of this upward trend can be attributed to recent regulations requiring an angling license for the taking of catfish and certain marine fishes not previously covered and lowering the minimum age at which a license is required.

It is not surprising that the success of individual anglers has declined as their numbers have increased. This has been the general trend for all types of angling. It has probably been at least partly the direct result of fishing pressure. More people have had to share the available crop of fish each year, and their individual shares have decreased accordingly. Another factor has been the large number of inexperienced newcomers to California, who have had to learn how and where to fish before competing on equal terms with long-time residents of the State.

Although the general trends of angling success are similar for all kinds of fresh-water and anadromous game fishes for which there are records, there is nevertheless considerable variation among them. They

will therefore be discussed separately in the summary of the postal card records which follows. This summary consists in large part of statistical tables and graphs. Much of it is important primarily as reference material. Readers who are more interested in the general aspects of surveys of this sort than in the detailed results obtained in California are referred especially to Part II, which takes up the 1948 study of non-response at length.

GENERAL DISCUSSION OF CATCH AND ANGLER ESTIMATES

The three principal trends obtained from these surveys for each kind of fish are the number of successful anglers, the average annual catch per angler, and the total catch. It is necessary to deal throughout with successful anglers rather than with the more general category of all anglers fishing for a species. Fishing days and numbers of anglers fishing unsuccessfully for the various kinds of fish cannot be obtained without unduly complicating the questionnaire and making it unsuitable for a postal card. As a result, postal card fishing effort figures are rather broad estimates, based on the number of anglers actually catching a given kind of fish in the course of the year. From all indications such estimates approximate the true figures rather closely.

The other two trends also have their limitations. The average annual catch per angler is based on a large number of approximations made by individual anglers. It can be assumed quite safely that few anglers will remember exactly how many fish of various kinds they caught during the preceding year. Comparison of a series of double postal card and interview reports made by the same anglers in 1948 reveals that some individuals give surprisingly different answers to the same questions on two occasions only a few weeks apart. However, in general the correlation between paired reports from the same individual was fairly high. The discrepancies occurred more or less at random, and tended to average out, with the end result that the average catch figures obtained for the same group on different occasions were generally in reasonably close agreement. These data are discussed in greater detail in Part II.

The limitations of the average catch estimates apply in equal measure to the total catch estimates, which are based upon them.

A great deal can be learned from these three trends, in spite of their limitations, which have been emphasized to prevent the reader from assuming that they are in the same class with comparable figures based on complete and objective catch records.

It is important to bear in mind, while reading the pages that follow, that the primary value of postal card catch per unit of effort estimates lies in the picture they provide of general angler success. For many reasons they are not very good indexes of abundance of the fish involved.

The whole matter of the statistical reliability and fiducial limits of the various types of estimates obtained from these surveys is of great interest. However, it is quite technical, and has therefore been included in Part II.

TRENDS IN CALIFORNIA TROUT ANGLING

Trout angling far outstrips all other types in popularity among California anglers. Any doubt about this was removed by the 1948 personal interview survey. One of the questions asked a random sample of

California anglers was, "Which of the kinds of fish on that card do you like best to fish for?" The kinds of fish on the card and percentages favoring each are shown in Table 3. Almost half of the whole group favored either trout or steelhead trout. It will also be seen from the fourth column of Table 4 that this preference is actually expressed in angling. Roughly 50 percent of all California angling licensees catch trout each year, and the 1948 interview survey revealed that in most cases these were the same individuals who placed trout first on their list of favorites.

TABLE 3

Fishing Preferences of California Anglers

	Percent of total sample preferring indicated fish		Percent of total sample preferring indicated fish
Steelhead trout	7.2	Catfish	4.5
Other trout	39.9	Barracuda	4.4
Salmon (ocean)	2.1	Abalone	1.1
Salmon (river)	3.6	Other ocean fish*	7.7
Striped bass	13.0	No preference	4.6
Black bass	9.7		
Crappie	1.7		
Sunfish	0.5	Total	100.0

* Includes in order of mention: Albacore, yellowtail, halibut, corbina, tuna, rockfish, and 20 others.

TABLE 4

Trends in California Trout Angling

Year	Total catch	Successful anglers		Annual catch per successful angler	
		Number	Percent of angling licensees	Mean	Median
1936	12,000,000	149,000	50	80	50
1937	11,900,000	151,000	48	78	50
1938	12,900,000	160,000	46	79	50
1939	12,800,000	179,000	49	71	37
1941	15,700,000	238,000	53	66	40
1942	16,400,000	234,000	54	70	42
1943	15,700,000	213,000	48	75	37
1946	17,660,000	357,000	47	49	25
1948	18,400,000	415,000	43	44	20

It is of interest to note that about the same proportion of all licensees have fished for trout each year since 1936, in spite of the great increase in the total number of anglers. Apparently the newcomers have fallen closely into the established pattern of California angling.

The continuing increase in trout anglers each year is graphed in the middle panel of Figure 55. Their numbers have almost tripled since 1936. There has been an accompanying increase of about 50 percent in the total annual trout catch, shown in the bottom graph. However, this latter increase has by no means kept pace with rising angling pressure. The top graph shows the sharp drop in the average annual trout catch per angler since 1943, when angling pressure began to increase most rapidly. These trout catch and angler estimates are summarized in Table 4.

Individual trout catches reported each year range all the way from one to a thousand or more. The mean (average) catch per successful angler has declined over the years from 80 in 1936 to 44 in 1948, as will

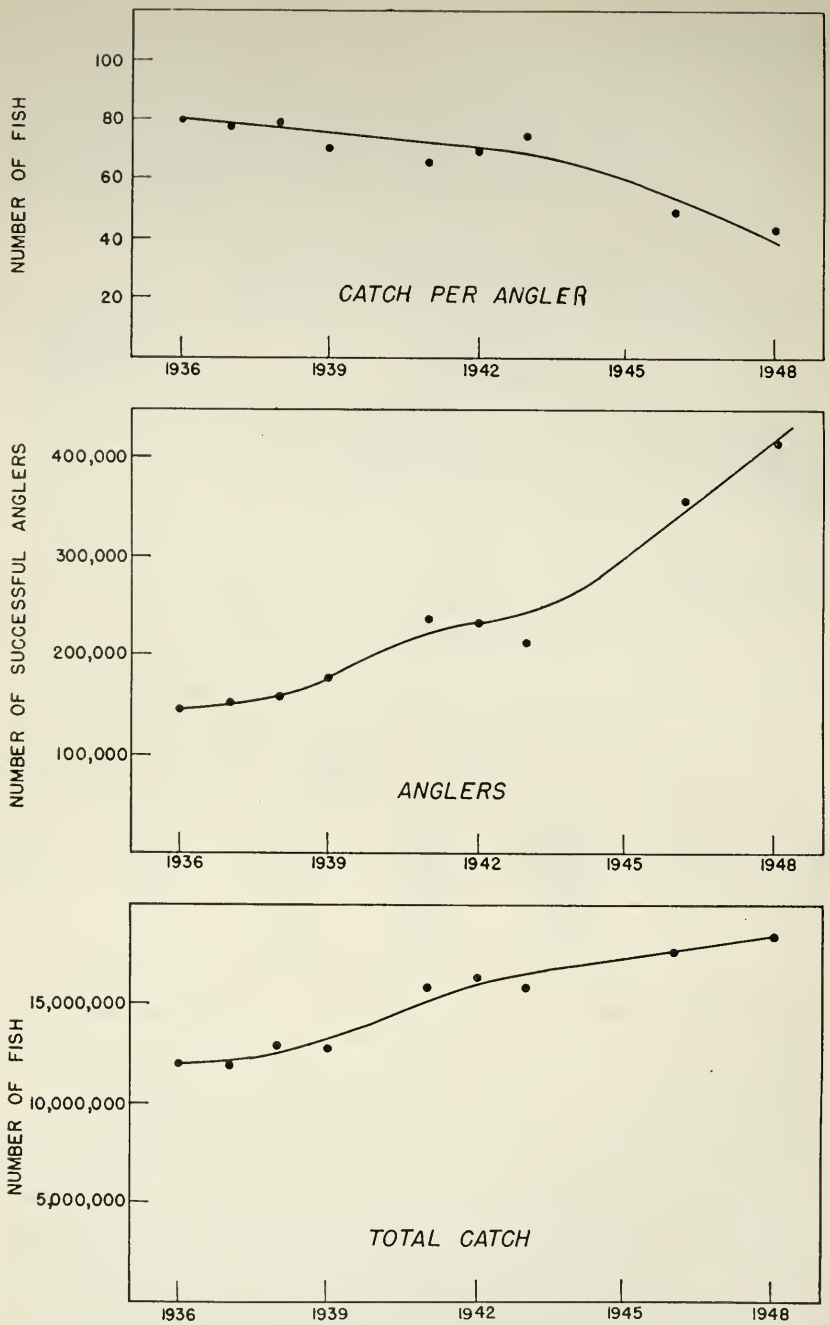

FIGURE 55. California trout angling trends.

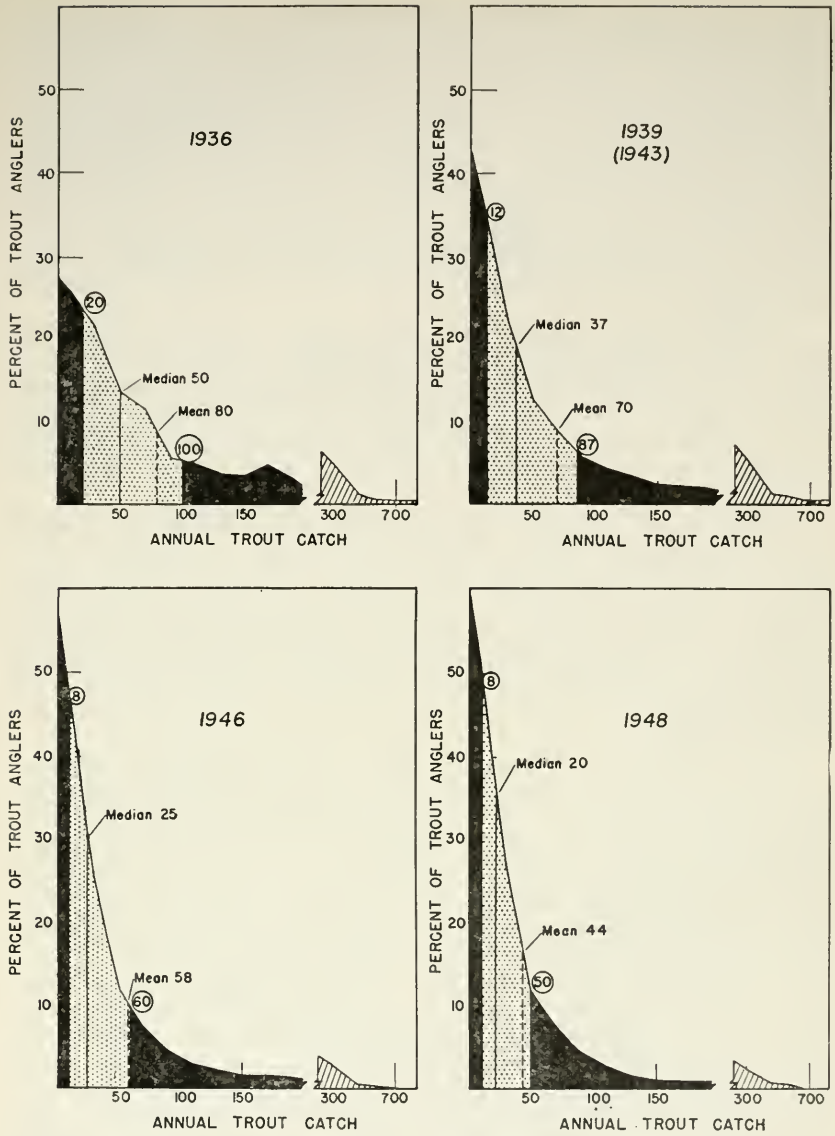

FIGURE. 56. Percentage frequencies of trout anglers by numbers of trout caught in various years.

be seen from Table 4. However, the mean catch is not a very good index of the general fishing success of anglers, because the catch frequency distributions are so strongly skewed that only about a fourth of all trout anglers take the average catch or more. The graphs in Figure 56 illustrate this point very well. They represent the smoothed frequency distributions of all trout anglers by the number of trout they caught annually during the years 1936, 1939, 1943, 1946, and 1948. The curves for 1939 and 1943 are almost identical, and the two are represented in this figure by the 1939 curve. Anglers who fished for trout but caught none are omitted from these distributions because they do not report such fishing on the questionnaires. Class intervals of 20 trout were used in preparing these graphs.

These frequency curves are all strongly J-shaped. In all cases more anglers caught from 1 to 20 trout than caught from 21 to 40. Similarly, more reported 41 to 60 than 61 to 80, and so on down the line; there are progressively fewer individuals in each succeeding category. The same type of curve is obtained when the data are plotted ungrouped.

Such curves are also characteristic of other species, for which examples are given in Part II.

Because of the peculiar shape of these curves the median catch is a more meaningful measure of individual angler success than is the mean. The median catch in 1948 was only 20 trout. In other words, roughly half of all successful trout anglers caught less than 20 trout and the other half caught more. In the 1948 personal interview survey the number of unsuccessful anglers was determined, and the median for all trout anglers, including those who caught none, was only 12 fish. The median catches from postal card surveys in the earlier years are also listed in Table 4.

The four curves in Figure 56 show the great changes which have occurred in the over-all picture of the success of individual California trout anglers during the past 13 years. The median catch, indicated by a solid vertical line, has shifted progressively to the left until in 1948 it is less than half the 1936 figure. The mean, shown by the broken line, has made a comparable shift. The solid black area to the left under these curves represents the least successful one-fourth of trout anglers. Catches of this group ranged from 1 to 20 in 1939 but were only from 1 to 8 in 1948. It will be recalled that unsuccessful trout anglers do not report as such in these postal card surveys, so there are no zero catches represented. Their inclusion would undoubtedly have further intensified the shift to the left shown in these curves. The black area to the right represents the most successful one-fourth of trout anglers. This group consisted of anglers catching 100 or more trout in 1939, but in 1948 the lower limit had dropped to 50. The hatched area at the extreme right of each is plotted on a class interval of 200 trout. It shows the change in the relative numbers of anglers reporting very large catches consisting of 200 or more trout. This group does not seem to have decreased as greatly as might have been expected.

The recent rapid decline in the success of individual trout anglers appears to have resulted primarily from the addition of several hundred thousand relatively unsuccessful anglers to the original group present in 1936. This is certainly suggested by Figure 57, which shows the first and last graphs from the preceding figure plotted by actual numbers of

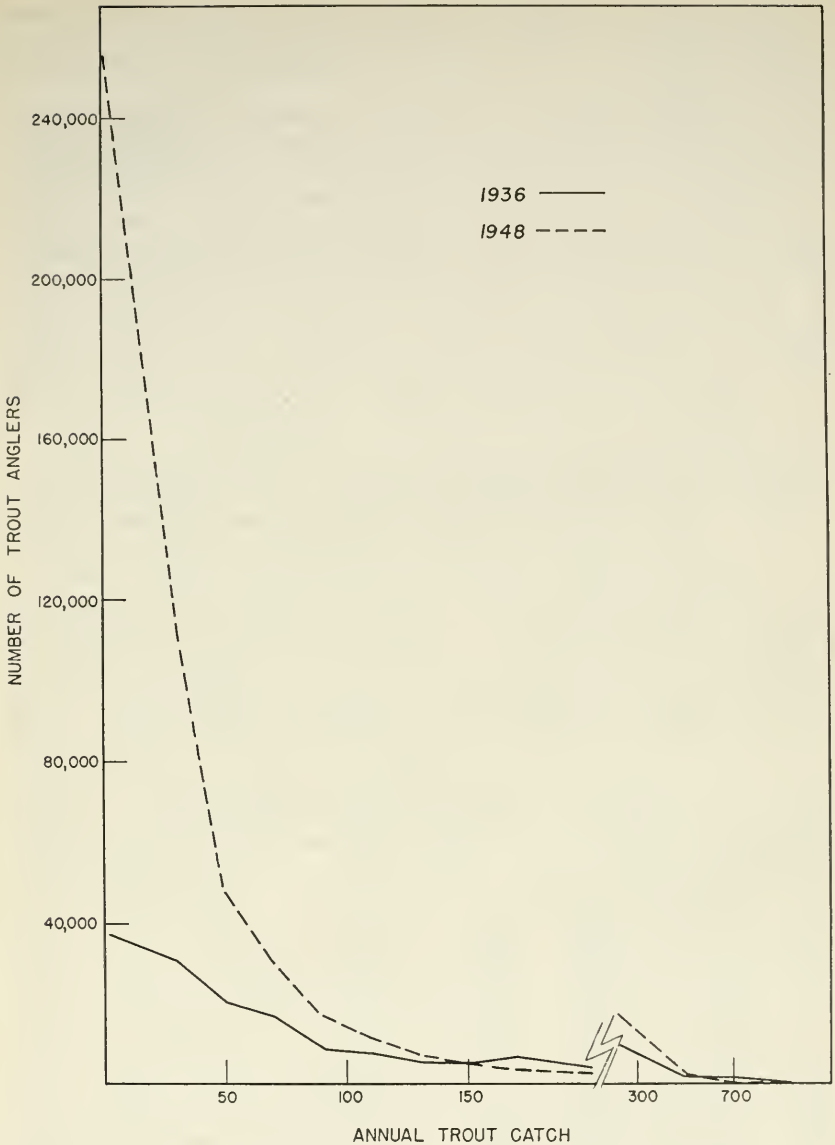

FIGURE 57. Frequency curves of numbers of trout anglers by trout caught in 1936 and 1948.

trout anglers rather than by percentage of all trout anglers. The increase in the numbers of relatively unsuccessful trout anglers has been tremendous, while the number of anglers catching 75 or more trout has not changed greatly.

The angling inexperience of many newcomers to the sport and the fact that most of them do not live near trout waters may be partly responsible for the large numbers of relatively unsuccessful trout anglers in recent years. The reduction of the daily bag limit from 25 to 15 trout, first effective in 1946, may also have had some influence. The fact that no surveys were made between 1943 and 1946 makes it difficult to evaluate this latter factor. No very apparent effect is evident in Figure 56. In the main, the general reduction in individual trout angler success probably represents an automatic rationing of the readily available annual trout crop among a greatly increased number of individuals.

This whole trout angling situation is reminiscent of the classical picture of a commercial fishery under very heavy exploitation. As the fishing effort for trout has increased, the total catch has followed it upward, but at a decreasing rate, and more and more anglers are each catching fewer and fewer fish. Of course it is an oversimplification to compare a sport fishery of this sort with generalized concepts relating to commercial fisheries. The relative inefficiency of angling compared with commercial fishing reduces the danger of seriously depleting a sport fishery. The fact that in the case of trout many small, isolated and highly variable populations are being fished further complicates the situation. Moreover, large-scale stocking of catchable trout each year clouds the issue, as does the recent dry cycle in California, which can scarcely have been beneficial to trout populations. Even so, the parallel is quite interesting. It suggests that we may be approaching a critical point in the exploitation of our valuable trout fisheries. There is at least an inference in Figure 55 that the readily available natural trout stocks approached maximum exploitation about 1943. Further significant increases in the total catch may have to depend upon increased exploitation of wilderness areas, improvement of natural waters to increase their trout production, and stocking of catchable trout. Unfortunately, stocking is very expensive and the amount which can be done with the funds available will probably always be small in relation to the natural production of wild fish. Moreover, present trends in water use in California are in most cases the opposite of those which would benefit trout. Diversion of water for domestic use, power, and irrigation is steadily drying up many of our streams, and the situation is not likely to improve in the future. The Division of Fish and Game does everything in its power to prevent and reduce diversions from trout streams, but the water requirements of California are such that the needs of fish must frequently take second place to power, irrigation, and domestic use.

TROUT CATCH AND ANGLER ESTIMATES FOR 1948 INCLUDING ZERO CATCHES

In 1948 we were able for the first time to estimate the numbers of anglers fishing unsuccessfully for the different kinds of fishes, using results from the special personal interview survey made that year. It was found that about 20 percent of all trout anglers were unsuccessful.

Table 5

Trout Catch and Angler Estimates From the 1948 Personal Interview Survey *

All trout anglers (including unsuccessful ones)	
Number	503,000
Percent of licensed anglers	53%
Mean annual trout catch	39.4
Median annual trout catch	12
Total days fished for trout	5,510,000
Mean days per angler	11
Mean daily catch	3.6
Successful trout anglers	
Number	401,000
Percent of licensed anglers	42%
Percent of all trout anglers	80%
Mean annual trout catch	48.0
Median annual trout catch	20
Unsuccessful trout anglers	
Number	102,000
Percent of licensed anglers	11%
Percent of all trout anglers	20%

* These figures differ slightly from those in the original ORC report because trout and steelhead have been combined.

Table 5 summarizes trout catch and angler estimates from the 1948 personal interview survey, for convenient reference.

TROUT ANGLING EFFORT AND SUCCESS IN 1948

Estimates of numbers of days of trout fishing and average daily bags were obtained for the first time on a state-wide basis in 1948. A frequency distribution of numbers of trout anglers and their catches by days fished is outlined in Table 6. It is based on the 1948 interview survey. Most anglers who fished for trout reported doing so for less

TABLE 6

Trout * Catch Per Angler Day, 1948 Interview Survey

Days fished for trout	Number of anglers	Angler days	Trout caught	Mean daily catch
1	75	75	192	2.6
2	73	146	424	2.9
3	83	249	799	3.2
4	48	192	651	3.4
5	44	220	908	4.1
6	32	192	600	3.1
7	46	322	868	2.7
8	28	224	935	4.2
9	15	135	507	3.8
10	40	400	1,379	3.4
11	5	55	172	3.1
12	15	180	831	4.6
13	10	130	562	4.3
14	24	336	1,079	3.2
15	21	315	1,196	3.8
16-20	33	642	3,426	5.3
21-29	22	525	2,810	5.3
Over 29	44	2,468	8,044	3.3
Totals	658	6,806	25,383	3.7

* Including steelhead.

than 10 days. About half of all trout anglers said they fished less than six days. There was little difference in the mean daily catches reported by anglers who fished a few days or many days for trout. The mean daily catch for all trout anglers was 3.7 trout per day.

COUNTY DISTRIBUTION OF THE 1948 TROUT CATCH

All postal card catch records are reported on a county of catch basis, and it is therefore readily possible to derive estimates of the numbers of fish caught in each of California's 58 counties. However, it must be emphasized that samples are small when such a breakdown is attempted so that the county estimates are no more than rough approximations. They are shown for the 1948 postal card survey for trout in Table 7 and in Figure 58. Each spot in this figure represents an annual county catch of 100,000 trout. Counties for which less than 25 trout catch reports were received are omitted from the table, but are included in the figure if the estimated catch exceeded 50,000 trout.

TABLE 7

County Distribution of the 1948 California Trout Catch

County of catch	Trout catch			Anglers catching trout
	Number of trout	Percent of state total	County rank	
Alpine	330,000	1.8	20	14,000
Amador	160,000	0.9	30	5,000
Butte	340,000	1.8	19	10,000
Calaveras	200,000	1.1	27	7,000
Del Norte	70,000	0.4	34	6,000
El Dorado	580,000	3.2	12	18,000
Fresno	730,000	4.0	6	23,000
Humboldt	710,000	3.9	9	21,000
Inyo	1,980,000	10.8	1	44,000
Kern	390,000	2.1	17	18,000
Lake	200,000	1.1	28	4,000
Lassen	190,000	1.0	29	10,000
Los Angeles	620,000	3.4	11	29,000
Madera	410,000	2.2	14	6,000
Mariposa	220,000	1.2	26	8,000
Mendocino	550,000	3.0	13	18,000
Modoc	270,000	1.5	23	6,000
Mono	1,790,000	9.7	2	52,000
Monterey	160,000	0.9	31	6,000
Napa	64,000	0.3	35	4,000
Nevada	400,000	2.2	16	10,000
Placer	320,000	1.7	22	11,000
Plumas	720,000	3.9	7	25,000
San Bernardino	960,000	5.2	3	44,000
San Diego	84,000	0.5	33	5,000
Santa Cruz	330,000	1.8	21	7,000
Shasta	620,000	3.4	10	13,000
Sierra	390,000	2.1	18	9,000
Siskiyou	730,000	4.0	5	14,000
Sonoma	240,000	1.3	25	8,000
Tehama	270,000	1.5	24	8,000
Trinity	720,000	3.9	8	16,000
Tulare	890,000	4.8	4	19,000
Tuolumne	400,000	2.2	15	16,000
Ventura	150,000	0.8	32	8,000

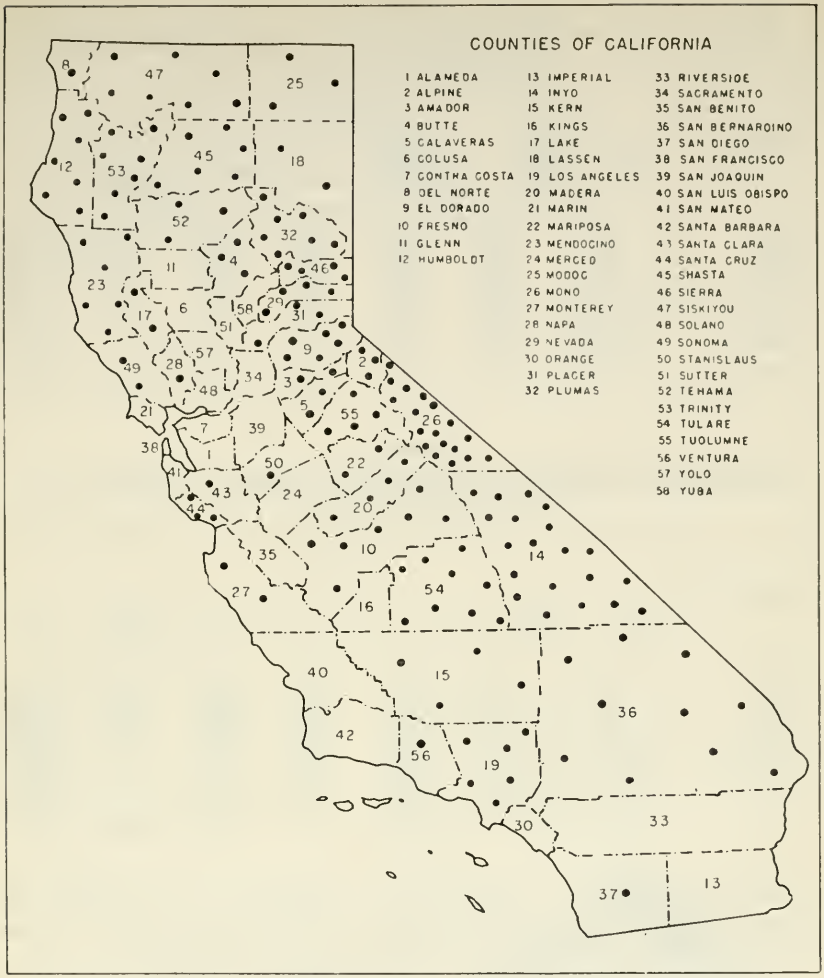

FIGURE 58. County distribution of the 1948 trout catch. Each spot represents 100,000 fish.

MIGRATIONS OF CALIFORNIA TROUT ANGLERS IN 1948

Information about trout angler migrations from postal card surveys aids in the development of an equitable stocking program. In making the 1948 analysis the State was divided into the eight catch districts and six residence areas outlined in the Appendix. Counties were combined in this way in order to obtain reasonably large samples. The general picture of 1948 trout angler migrations revealed by the 1948 postal card survey is outlined in Tables 8 and 9. Migrations from Southern California and the San Francisco Bay area, the two most important residence areas, are shown graphically in Figure 59. Each solid arrow represents a migration of 10,000 anglers. Arrows with

TABLE 8

Numbers of Successful Trout Anglers Moving From Residence Areas to Fish Management Districts

Fish management districts	Residence areas						
	Southern California	Southern Central California	San Francisco	San Joaquin	Sacramento	Northern California	Totals
1. Shasta	2,828	665	13,978	998	3,993	14,643	37,105
2. Lassen	6,157	665	18,970	1,497	12,147	10,649	50,085
2. Tahoe	6,489	2,329	29,620	12,813	21,133	832	73,216
4. Central	1,164	332	4,326	1,497	2,496	166	9,981
5. Coast	6,323	3,827	43,931	832	3,328	10,649	68,890
6. San Joaquin	29,121	30,951	5,824	2,662			68,558
7. Mt. Whitney	69,391	11,315	3,660	166	832	332	85,696
8. Southern	82,703	332	499		166		83,700
Totals	204,176	50,416	120,808	20,465	44,095	37,271	477,231

TABLE 9

Numbers of Trout Caught in Fish Management Districts by Anglers From Six Residence Areas

Fish management districts	Residence areas						
	Southern California	Southern Central California	San Francisco	San Joaquin	Sacramento	Northern California	Totals
1. Shasta	58,492	47,592	401,787	69,391	220,072	1,219,673	2,017,007
2. Lassen	126,353	36,776	437,897	31,950	512,280	677,356	1,822,612
3. Tahoe	144,607	48,091	808,733	518,854	1,165,174	16,474	2,701,933
4. Central	19,969	12,647	129,131	48,424	69,558	1,997	281,726
5. Coast	99,178	128,465	1,672,213	9,656	106,333	540,320	2,556,165
6. San Joaquin	708,557	1,566,217	204,180	275,735			2,754,689
7. Mt. Whitney	2,812,095	845,176	70,889	9,984	23,962	666	3,762,772
8. Southern	1,925,817	3,162	4,160		2,496		1,935,635
Totals	5,895,068	2,688,126	3,728,990	963,994	2,099,875	2,456,486	17,832,539

broken shafts represent from 1,000 to 5,000 anglers. Each large fish indicates 500,000 trout caught in the area where it is shown by anglers following the arrows. Each small fish represents 100,000 trout.

The extent to which anglers from Southern California spread out over the State to fish for trout is quite remarkable. Comparison with corresponding migrations shown by the 1948 personal interview survey is made in Part II.

TRENDS IN CALIFORNIA STRIPED BASS ANGLING

It has already been mentioned that one of the important purposes of the whole California postal card survey program is to obtain reliable striped bass trends. For this fishery above all it is desirable to have good fishing effort and catch per unit of effort estimates. Unfortunately, all that is obtained from the postal card surveys is the number of anglers catching striped bass each year and their estimated annual catch. The limitations of such figures as indexes of fishing pressure and abundance, respectively, are too obvious to require elaboration. Nevertheless they

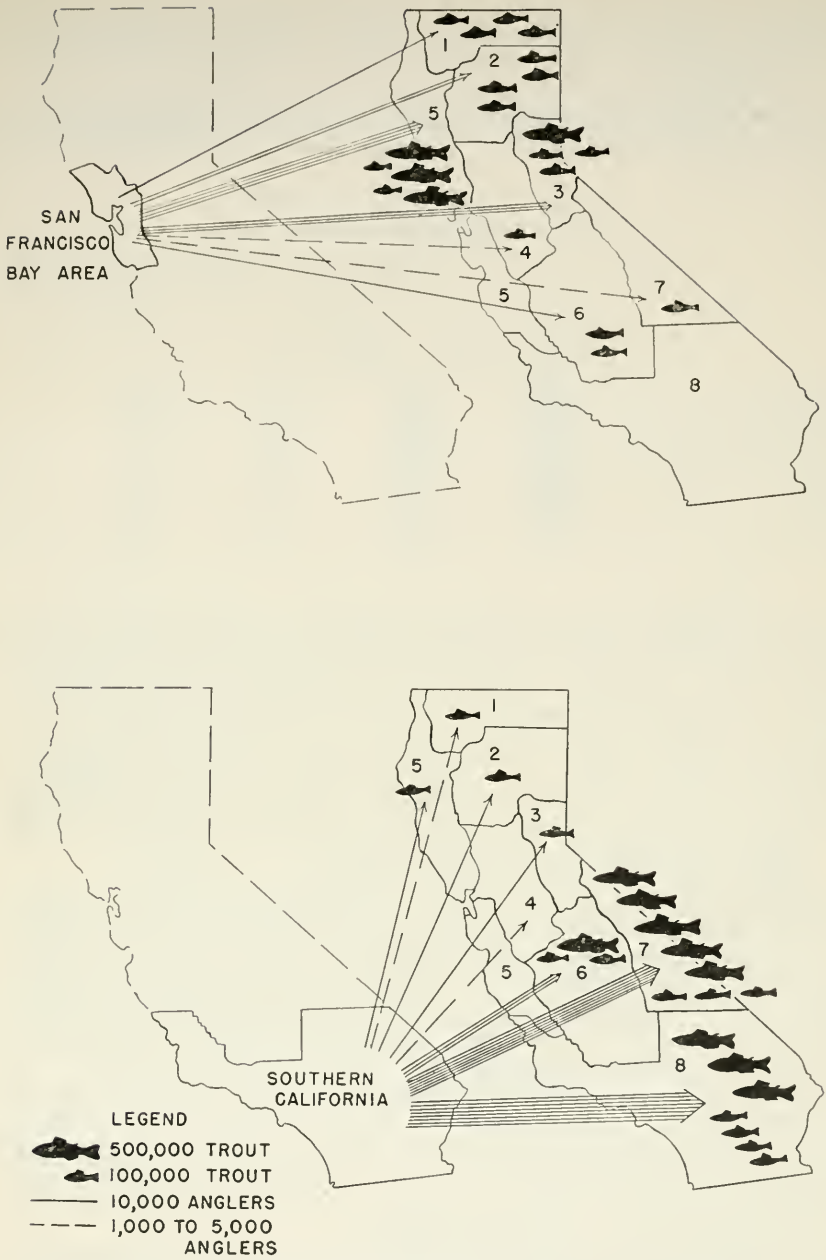

FIGURE 59. Migrations of trout anglers living in Southern California and in the San Francisco Bay Area.

are very valuable for they make it possible to follow the general over-all picture of what is happening in the fishery. Without them this would be impossible.

The total yearly catch of striped bass, shown in Table 10 and Figure 60, has remained surprisingly constant since 1936, although there has been a slight downward trend in recent years.

TABLE 10

Trends in California Striped Bass Angling

Year	Total catch	Successful anglers		Annual catch per successful angler	
		Number	Percent of angling licensees	Mean	Median
1936	2,110,000	84,400	28	25	
1937	2,040,000	81,900	26	25	
1938	1,940,000	92,800	27	21	
1939	1,880,000	89,300	24	21	12
1941	1,940,000	106,000	23	18	10
1942	1,680,000	88,200	20	19	
1943	1,680,000	75,000	17	22	9
1944	1,420,000				
1946	1,380,000	113,000	15	12	6
1948	1,650,000	161,000	17	10	5

The number of successful anglers has also remained relatively constant until quite recently. The first indication of a real increase in this latter figure occurred in 1948, long after the big increase had taken place for most other fish. Apparently the newcomers to the San Francisco Bay area during and immediately after the war took several years to become oriented with respect to striped bass fishing, which requires a somewhat higher degree of organization than most other California angling. It is probable that the sudden sharp rise in striped bass anglers in 1948 is the beginning of a new trend, and that this fishery will experience increasing pressure in the future.

The mean and median annual catches per successful striped bass angler, shown in Table 10, indicate a generally lower level of angler success since 1946 than previously. As with the other kinds of fish, most of this drop is probably simply a reflection of the inexperience of anglers new to this type of fishing. The limitations of these mean annual catch figures as indexes of abundance have already been mentioned. In the case of striped bass their downward trend is thought to indicate no more than a possible rather small decrease in abundance. To remove any doubt on this point, attention is called to the corresponding figures for salmon, given in a later section. Commercial fishing records reveal that the general abundance of salmon in California showed a phenomenal increase in 1945 and 1946 (Fry, 1949), but even so the mean catch of salmon per successful angler was less in 1946 than in previous years, when these fish were much less abundant.

Other striped bass records from the party boat fishery provide a better index of striped bass abundance. They have been discussed in a previous report (Calhoun, 1949).

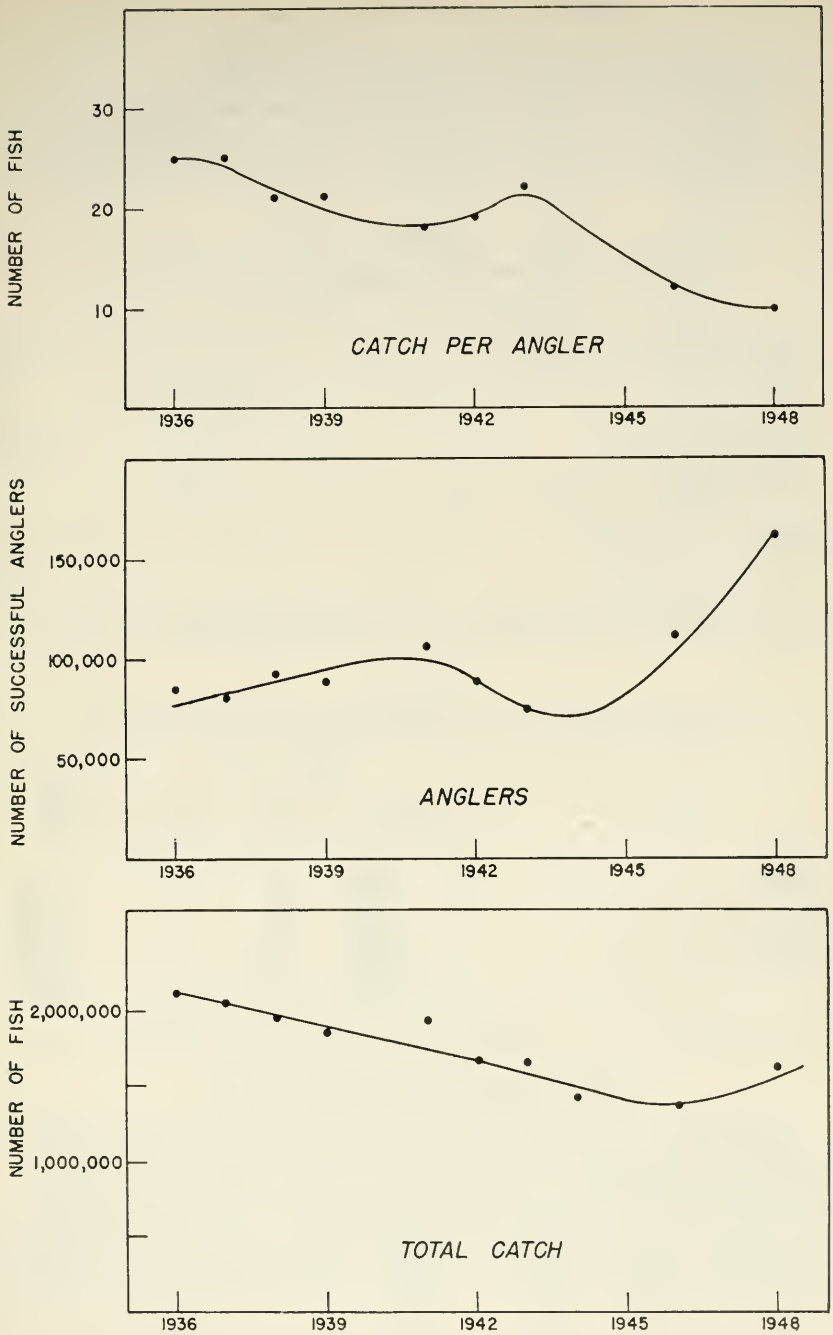

FIGURE 60. California striped bass angling trends.

OTHER STRIPED BASS ESTIMATES

Striped bass estimates for 1948 from the personal interview survey, including unsuccessful anglers, are outlined in Table 11.

County distribution of the 1948 striped bass catch, from the postal card survey, is outlined in Table 12 and diagramed in Figure 61. Almost the entire catch every year is taken from the Sacramento-San Joaquin River system.

TABLE 11

Striped Bass Catch and Angler Estimates for 1948 From the Personal Interview Survey *

All striped bass anglers (including unsuccessful ones)	
Number	250,000
Percent of licensed anglers	26%
Mean annual catch	8.7
Median annual catch	3
Successful striped bass anglers only	
Number	170,000
Percent of licensed anglers	18%
Percent of all striped bass anglers	68%
Mean annual catch	12.7
Median annual catch	5
Unsuccessful striped bass anglers only	
Number	80,000
Percent of licensed anglers	8%
Percent of all striped bass anglers	32%

* These figures differ from those in the original ORC report because striped bass angling reported in impossible locations has been eliminated. These fish are sometimes confused with other kinds of bass in Southern California and elsewhere.

TABLE 12

County Distribution of the 1948 California Striped Bass Catch

County * of catch	Striped bass catch			Anglers catching striped bass
	Number of striped bass	Percent of state total	County rank	
Alameda	40,000	2.4	8	6,000
Contra Costa	520,000	31.5	1	53,000
Marin	70,000	4.2	6	7,000
Napa	120,000	7.3	5	10,000
Sacramento	190,000	11.5	4	20,000
San Francisco	56,000	3.4	7	10,000
San Joaquin	200,000	12.1	3	28,000
Solano	210,000	12.7	2	23,000

* Counties for which less than 25 striped bass catch reports were received are omitted from the table but are included in the accompanying spot diagram.

RECORDS FOR WARM-WATER FISHES

The warm-water game fishes present in California include the black basses, sunfishes, crappies, and catfishes (Curtis, 1949). All but the sunfishes show the same general trends, as can be seen from the accompanying graphs and tables. Estimates for sunfish and crappie are not shown for the early license stub surveys because figures are not comparable with those from postal cards. Anglers tended to neglect these fish on the license stub questionnaires.

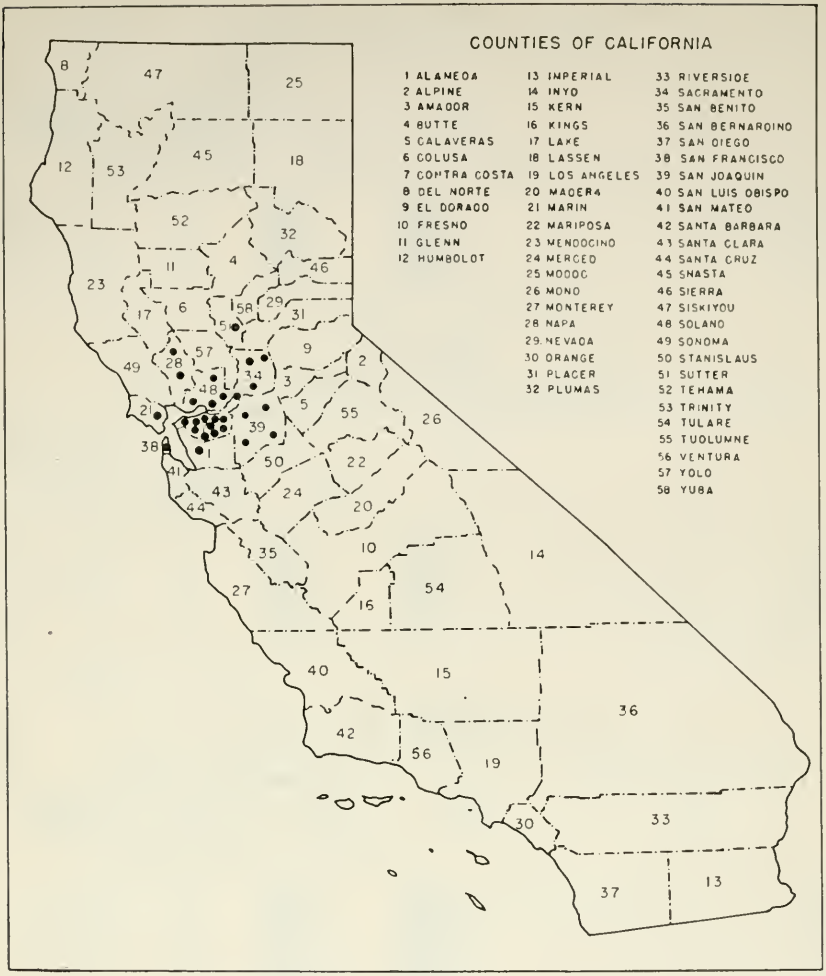

FIGURE 61. County distribution of the 1948 striped bass catch. Each spot represents 50,000 fish.

TABLE 13

Trends in California Black Bass Angling

Year	Total catch	Successful anglers		Average catch of successful anglers
		Number	Percent of angling licensees	
1936	930,000	34,000	11	27
1937	849,000	33,000	11	26
1938	1,190,000	46,000	13	26
1939	1,340,000	67,000	18	20
1941	1,530,000	75,000	17	20
1942	1,340,000	66,000	15	20
1943	1,570,000	79,000	18	20
1946	1,700,000	101,000	14	16
1948	1,890,000	128,000	13	15

TABLE 14

Trends in California Crappie Angling

Year	Total catch	Successful anglers		Average catch of successful anglers
		Number	Percent of angling licensees	
1939	1,720,000	52,000	14	33
1941	2,180,000	70,000	15	31
1942	2,620,000	66,000	15	40
1943	2,670,000	76,000	17	35
1946	3,040,000	106,000	14	29
1948	2,760,000	116,000	12	24

TABLE 15

Trends in California Sunfish Angling

Year	Total catch	Successful anglers		Average catch of successful anglers
		Number	Percent of angling licensees	
1939	2,090,000	51,000	14	41
1941	2,770,000	63,000	14	44
1942	3,060,000	57,000	13	54
1943	3,040,000	68,000	15	45
1946	4,320,000	122,000	16	35
1948	4,820,000	118,000	12	41

TABLE 16

Trends in California Catfish Angling

Year	Total catch	Successful anglers		Average catch of successful anglers
		Number	Percent of angling licensees	
1936	2,940,000	38,000	13	78
1937	2,810,000	43,000	14	65
1938	3,480,000	48,000	14	72
1939	4,330,000	75,000	20	58
1941	6,100,000	97,000	21	63
1942	8,250,000	110,000	25	75
1943	7,060,000	101,000	23	70
1946	6,530,000	149,000	19	44
1948	5,560,000	182,000	19	31

The number of anglers fishing for warm-water varieties appears to have increased roughly in proportion to the increase in the total number of licensed anglers. The total catches in each case also have increased greatly, but not enough to maintain the initial high average catches except in the case of sunfish. Changes in bag limits and other regulations greatly complicate the picture. As in the case of the other kinds of fishes covered in these surveys, the drop in the average catch per angler probably has had little connection with changes in abundance.

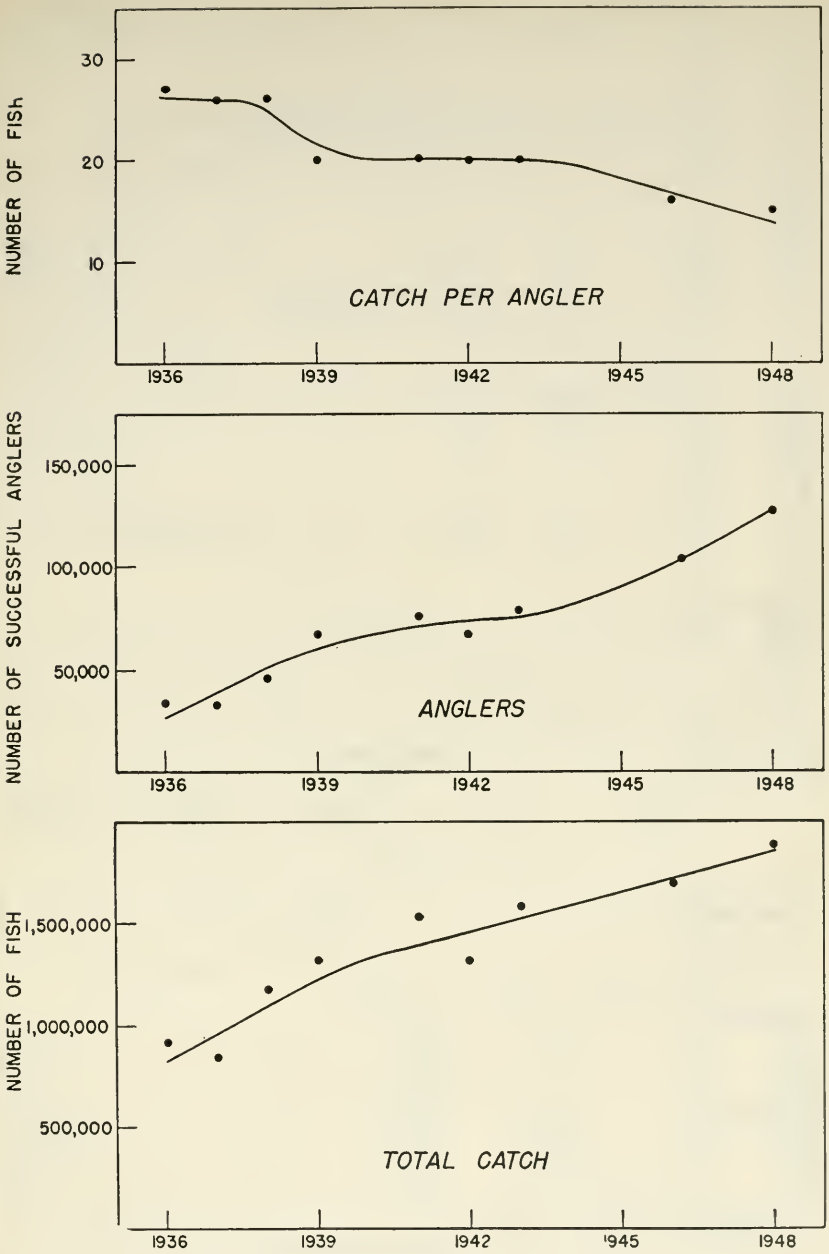

FIGURE 62. California black bass angling trends.

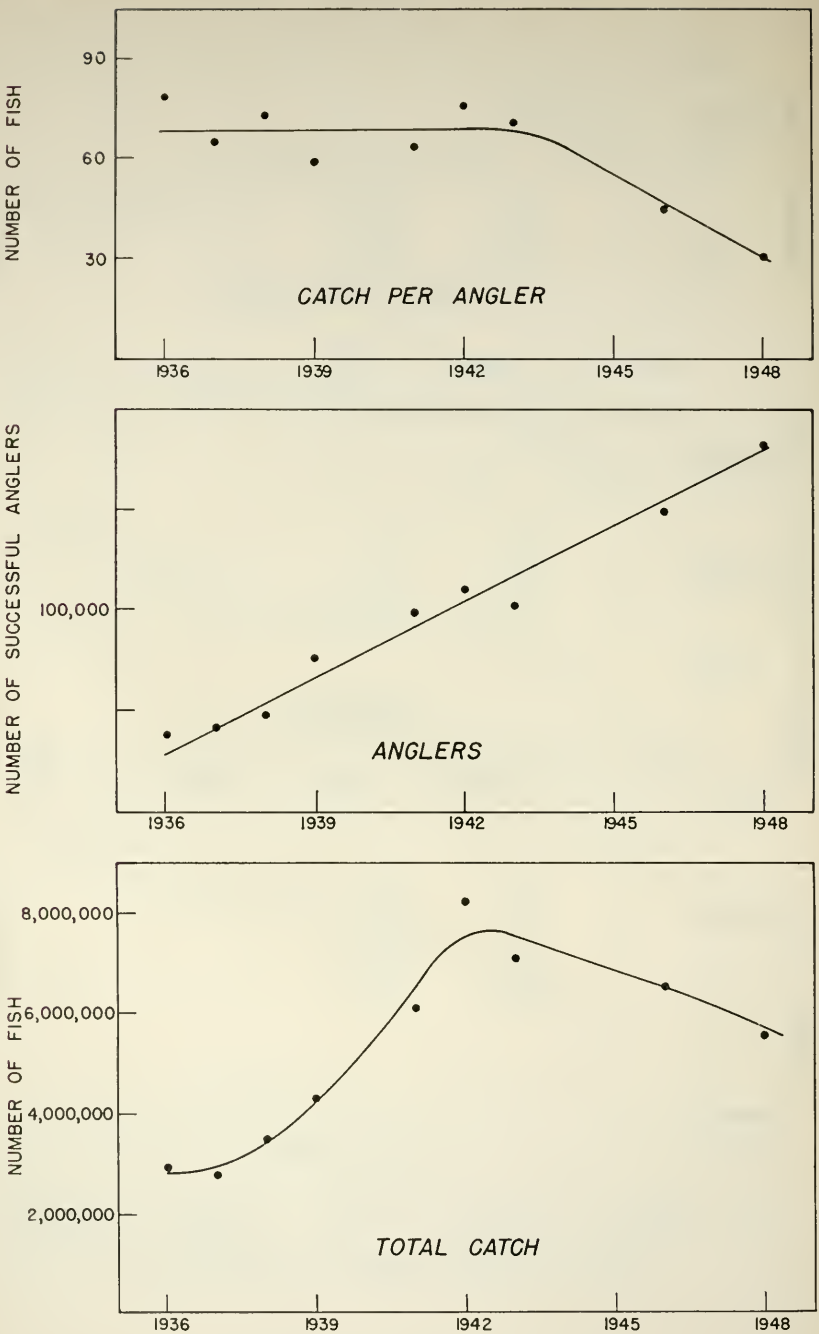

FIGURE 63. California catfish angling trends.

Estimates from the personal interview survey pertaining to 1948 angling for warm-water fishes are outlined in Table 17.

TABLE 17

Warm-water Fish Catch and Angler Estimates for 1948 From the Personal Interview Survey

	Black bass	Crappie	Sunfish	Catfish
All anglers, including unsuccessful ones				
Number	210,000	181,000	118,000	258,000
Percent of licensed anglers	22.0%	18.9%	12.3%	27.0%
Mean annual catch	10.7	22.9	39.0	33.8
Median annual catch	3	10	17	12
Total days fished	1,400,000	1,030,000	859,000	1,960,000
Mean days per angler	6.7	5.7	7.2	7.6
Mean daily catch	1.6	4.0	5.4	4.4
Successful anglers only				
Number	144,000	153,000	103,000	219,000
Percent of licensed anglers	15.1%	16.0%	10.7%	22.9%
Percent of anglers for the fish	69%	85%	87.4%	84.9%
Mean annual catch	15.6	27.2	44.4	39.8
Median annual catch	6	15	20	15
Unsuccessful anglers				
Number	66,000	28,000	15,000	39,000
Percent of licensed anglers	6.9%	2.9%	1.6%	4.1%
Percent of anglers for the fish	31%	15%	12.6%	15.1%

One of the most remarkable features of the California bass, crappie, and sunfish take is its concentration in the southern part of the State. This is very apparent from the spot diagrams showing the county distribution of catches of these fish. In the black bass diagram each spot represents 25,000 fish, while in the other three each one represents 50,000 fish. Actual county totals from the postal card survey are given in the accompanying tables. Catfish, unlike these others, are caught mainly in the Sacramento-San Joaquin Delta.

TABLE 18

County Distribution of the 1948 Black Bass Catch

County * of catch	Black bass catch			Anglers catching black bass
	Number of black bass	Percent of state total	County rank	
Fresno	85,000	4.5	7	9,000
Imperial	100,000	5.3	3	4,000
Lake	99,000	5.2	4	9,000
Los Angeles	92,000	4.9	5	8,000
Riverside	91,000	4.8	6	5,000
Sacramento	75,000	4.0	8	7,000
San Bernardino	154,000	8.1	2	11,000
San Diego	500,000	26.4	1	33,000
San Joaquin	60,000	3.2	9	7,000
Stanislaus	46,000	2.4	10	4,000

* Counties for which less than 25 black bass catch reports were received are omitted from the table but are included in the accompanying spot diagram.

TABLE 19

County Distribution of the 1948 Crappie Catch

County * of catch	Crappie catch			Anglers catching crappie
	Number of crappie	Percent of state total	County rank	
Lake	80,000	2.9	5	5,000
Los Angeles	110,000	4.0	4	5,000
Orange	130,000	4.7	3	6,000
San Bernardino	400,000	14.5	2	18,000
San Diego	1,500,000	54.4	1	57,000

* Counties for which less than 25 crappie catch reports were received are omitted from the table, but are included in the accompanying spot diagram.

TABLE 20

County Distribution of the 1948 Sunfish Catch

County * of catch	Sunfish catch			Anglers catching sunfish
	Number of sunfish	Percent of state total	County rank	
Fresno	80,000	1.7	8	4,000
Lake	200,000	4.1	5	5,000
Los Angeles	400,000	8.3	3	8,000
Orange	210,000	4.4	4	5,000
Sacramento	170,000	3.5	6	4,000
San Bernardino	480,000	10.0	2	15,000
San Diego	1,880,000	39.0	1	42,000
San Joaquin	150,000	3.1	7	4,000

* Counties for which less than 25 sunfish catch reports were received are omitted from the table but are included in the accompanying spot diagram.

TABLE 21

County Distribution of the 1948 Catfish Catch

County * of catch	Catfish catch			Anglers catching catfish
	Number of catfish	Percent of state total	County rank	
Contra Costa	690,000	12.4	2	21,000
Imperial	220,000	4.0	6	5,000
Lake	530,000	9.5	4	21,000
Los Angeles	60,000	1.1	12	4,000
Riverside	70,000	1.3	11	4,000
Sacramento	530,000	9.5	3	17,000
San Bernardino	180,000	3.2	8	13,000
San Diego	220,000	4.0	5	14,000
San Joaquin	1,220,000	22.0	1	26,000
Solano	190,000	3.4	7	8,000
Stanislaus	150,000	2.7	9	7,000
Yolo	100,000	1.8	10	4,000

* Counties for which less than 25 catfish catch reports were received are omitted from the table but are included in the accompanying spot diagram.

FIGURE 64. County distribution of the 1948 black bass catch. Each spot represents 25,000 fish.

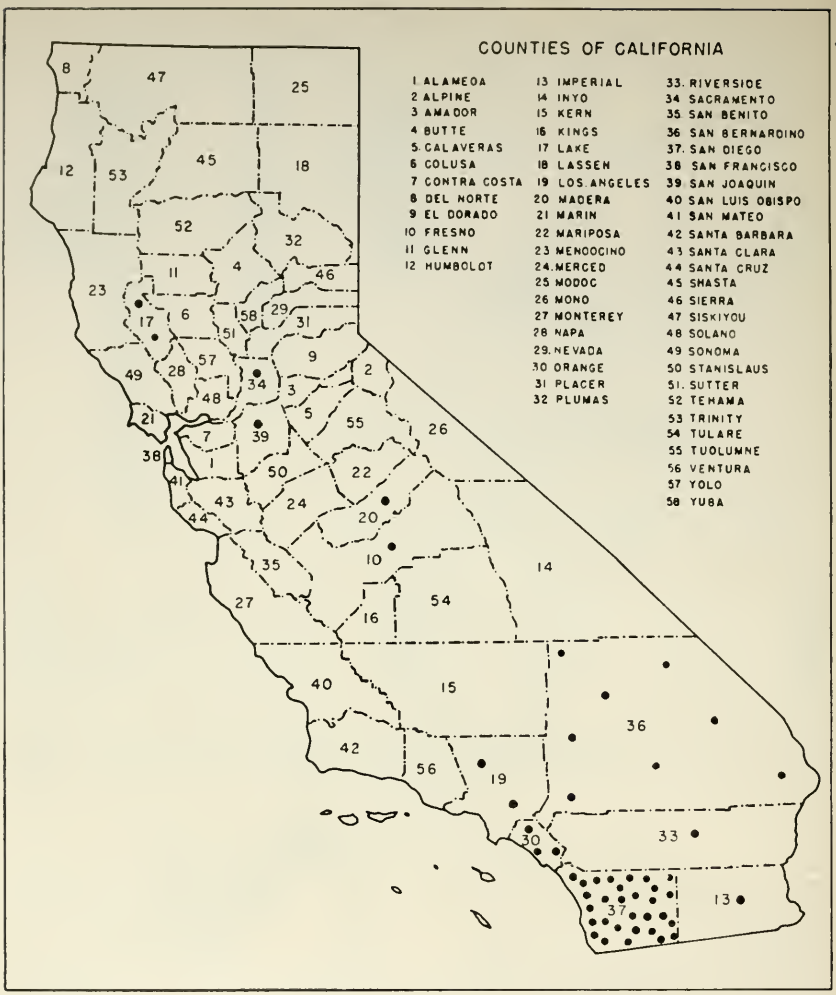

FIGURE 65. County distribution of the 1948 crappie catch. Each spot represents 50,000 fish.

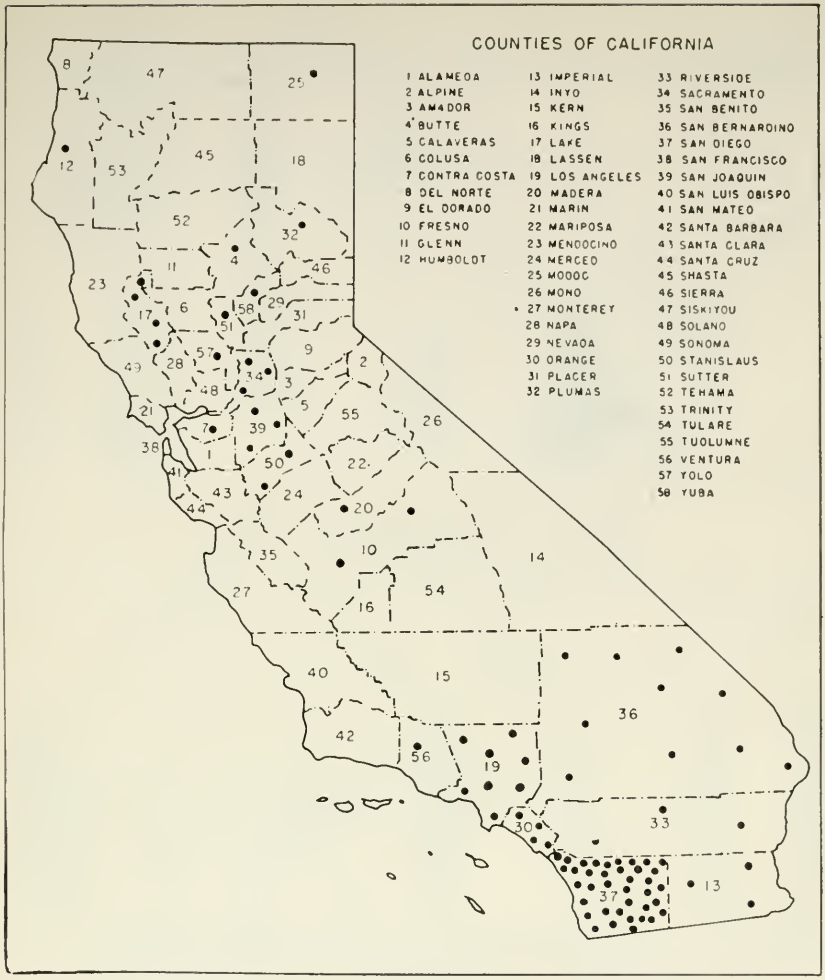

FIGURE 66. County distribution of the 1948 sunfish catch. Each spot represents 50,000 fish.

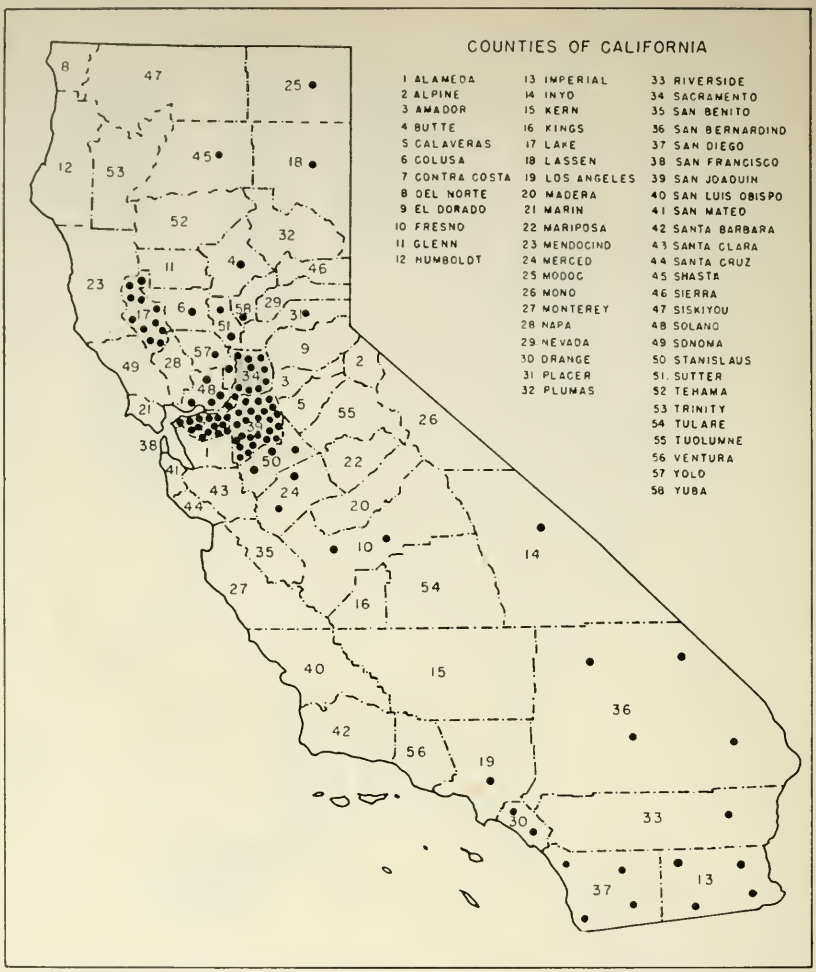

FIGURE 67. County distribution of the 1948 catfish catch. Each spot represents 50,000 fish.

SALMON CATCH RECORDS

Salmon angling trends are shown in Table 22 and Figure 68. They do not differ in any important respect from the other fish already dis-

TABLE 22

Trends in California Salmon Angling

Year	Total catch	Successful anglers		Average catch of successful anglers
		Number	Percent of angling licensees	
1936	196,000	25,000	8	8
1937	160,000	20,000	6	8
1938	178,000	22,000	6	8
1939	215,000	31,000	8	7
1941	253,000	38,000	8	7
1942	180,000	32,000	7	6
1943	274,000	31,000	7	9
1946	291,000	50,000	7	6
1948	321,000	65,000	7	5

TABLE 23

County Distribution of the 1948 Salmon Catch

County * of catch	Salmon catch			Anglers catching salmon
	Number of salmon	Percent of state total	County rank	
Butte	9,000	2.8	9	3,000
Del Norte	22,000	6.8	4	7,000
Humboldt	49,000	15.4	2	10,000
Marin	17,000	5.3	5	5,000
Mendocino	27,000	8.4	3	6,000
Sacramento	4,000	1.2	12	2,000
San Francisco	59,000	18.4	1	8,000
San Joaquin	14,000	4.4	7	5,000
Shasta	9,000	2.8	10	2,000
Stanislaus	9,000	2.8	11	3,000
Tehama	15,000	4.7	6	4,000
Trinity	10,000	3.1	8	2,000

* Counties for which less than 12 salmon catch reports were received are omitted from the table, but are included in the accompanying spot diagram.

TABLE 24

Comparison of Ocean and River Angling for Salmon in 1948, From the Personal Interview Survey

	Ocean salmon angling	River salmon angling	All salmon angling
Number of salmon anglers in the sample	62	126	*171
All salmon anglers (including unsuccessful ones)	47,500	96,500	130,000
Percent of all anglers	5.0%	10.1%	13.6%
Mean annual catch	4.7	1.8	2.8
Total days fished	215,000	680,000	895,000
Mean days per angler	4.5	7.0	6.9
Total catch	222,000	173,000	395,000
Mean daily catch	1.0	0.26	0.44

* This is slightly less than the sum of the other two groups because a few individuals did both types of salmon angling; 96 of the 171 did not catch any salmon.

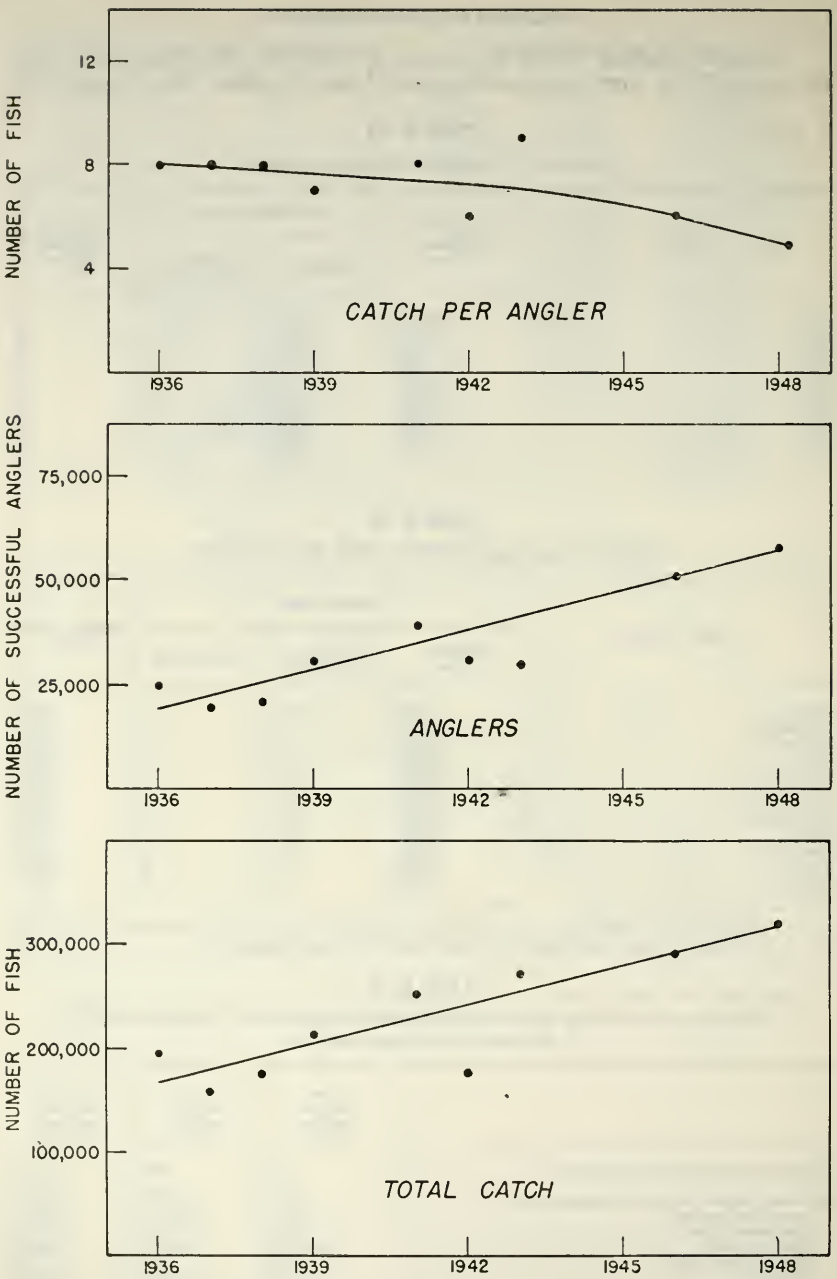

FIGURE 68. California salmon angling trends.

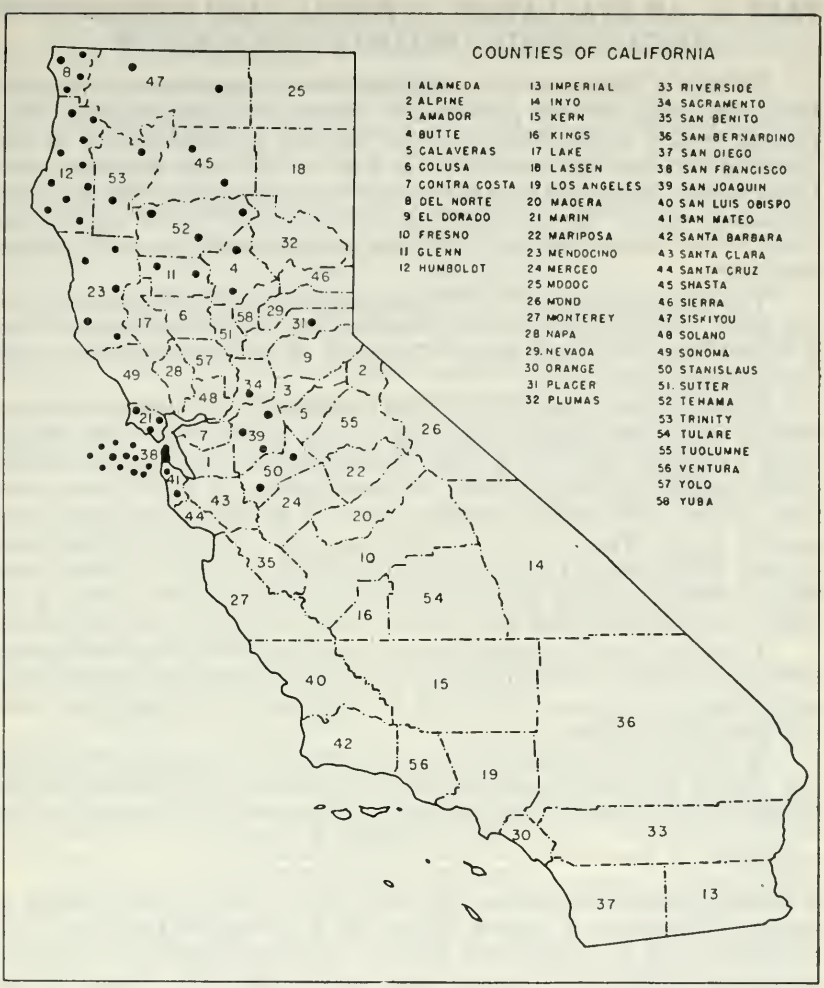

FIGURE 69. County distribution of the 1948 salmon catch. Each spot represents 5,000 fish.

cussed. The number of anglers has increased and the total catch has also risen, but the average annual catch has declined.

The county distribution of the 1948 salmon catch from the postal card survey is outlined in Table 23 and charted in Figure 69 in which each spot represents 5,000 salmon. The individual county samples are quite small because relatively few California anglers actually catch salmon.

Salmon catch and angler estimates from the 1948 personal interview survey are summarized in Table 24, which includes a comparison of ocean and river salmon angling. This table is mainly for reference and is self-explanatory.

PART II—AN EVALUATION OF POSTAL CARD NONRESPONSE IN CALIFORNIA ANGLING CATCH SURVEYS

In 1948 a large-scale personal interview survey was made in addition to the usual one with postal cards. The objective was to obtain catch reports from a sizable number of the kind of individuals who do not return postal card questionnaires, and to see how they compared with those who do. The postal card survey that year was made in the same way as preceding ones. The random 2 percent sample of 18,678 anglers was obtained by drawing the first stub from every second book of 25 angling licenses.*

The original sample of 18,678 names approached the 2 percent objective closely. Total license sales in 1948 were 960,027.† Two percent of this is 19,200, indicating that about 97 percent of all licensed anglers were actually sampled.

Usable returns totaled 5,751. This amounted to 31.8 percent of those mailed. Successful anglers reporting one or more of the eight species listed accounted for 4,086 of these returns. Another 290 were from successful anglers who caught other, unlisted species, or who failed to note what species they caught, making a total of 4,376 (76.1%) successful anglers in all. There were an additional 943 (16.4%) returns from anglers who fished but did not catch anything, 312 (5.4%) from those who purchased angling licenses but did not fish, and 120 (2.1%) from those who caught nothing but failed to state whether or not they fished.

The actual catch estimates derived from this 1948 postal card survey have already been outlined in Part I of this report. However, considerable additional information about them is contained in the statistical comparisons which follow.

In converting postal card returns to state-wide estimates the assumption is made that they represent a true cross-section of California anglers. On this basis the various characteristics of the postal card sample can be multiplied by the ratio: $\frac{\text{Total number of anglers}}{\text{Number of postal card reports}}$ to obtain state-wide estimates. This applies to numbers of fish caught as well as to numbers of anglers fishing for a particular species or in a particular area. In practice the number of licensed anglers is used as a numerator, and the 1948 postal card survey projection factor is consequently: $\frac{957{,}000\ ‡}{5{,}751} = 166.4$

The 1948 personal interview survey was conducted as a parallel but largely independent project. It was carried on by the Opinion Research Center of the University of Denver, which will subsequently be referred to simply as ORC. This nonprofit, research organization ceased operation in September of 1949. Mr. Don Cahalan and Miss Helen Crossley directed the project, working in close cooperation with members of the California Division of Fish and Game.

* Questionnaires were withheld from 608 anglers, at random, for special reasons. The number of postal cards actually mailed were therefore only 18,070.

† This estimate was obtained in February of 1950. It is not the final one, but is close to it.

‡ This was the best estimate available when the report was prepared, and it has been used throughout unless otherwise indicated.

The personal interview sample was predetermined at 1,250 anglers. The large expense connected with such a project made it impractical to interview more than this number, which was considered adequate for obtaining state-wide total catch and angler estimates. The sample was drawn at random from the postal card sample, on a county basis, to assure adequate distribution over the State as a whole. The number of resident anglers to be interviewed in each county was derived from the proportion of corresponding county residents in the total postal card sample. Then, for each county, the interviewees were selected at random from the total postal card sample for that county.

The original list of 1,250 interviewees also included an alternate for each two respondents, as a safety measure. These alternates were also drawn at random, in exactly the same way as the originals. Considerable difficulty was encountered in locating respondents in many instances, but 71.4 percent of all interviewees were nevertheless from the original list, the remainder being alternates. The latter were always selected at random from the same county as the individual they replaced. Several times, in the case of very small counties, it was necessary to return to the original postal card sample for a name, but not frequently enough for this to be of any consequence.

In order to permit interviewing assignments of practicable size, 10 small counties were combined with similar neighboring counties. In such cases, the interviews required for the group were all taken from a single representative county.*

Respondents were sent letters of explanation before they were interviewed. This usually facilitated the interviews.

The interview questionnaire was drawn up jointly by ORC and the California Division of Fish and Game. Pretesting in Denver and the San Francisco Bay area was followed by an extensive pilot study involving 50 actual trial interviews in and around San Francisco. Results of this pilot study were used to set up the final ballot, a portion of which is illustrated in Figure 70.

Interviewing for the angling survey and a parallel hunting survey was carried on together, although the samples were entirely distinct. The field interviewing staff was built around a nucleus of experienced interviewers of the National Opinion Research Center of the University of Chicago. All interviewers received careful personal training in survey techniques.

Our original plan had been to send postal card questionnaires to all individuals before they were interviewed, in order to obtain the largest possible sample upon which to evaluate nonresponse. However, ORC feared that receipt of a postal card prior to the interview might have some peculiar influence upon it. Therefore, they insisted that we withhold cards from a third of their respondents, and this was done.

The whole procedure of selecting the personal interview sample was carried on by the Division of Fish and Game. ORC was presented with the names and addresses of 1,250 respondents and 625 alternates, selected in the manner already outlined. They then assumed full responsibility for the remainder of the project and presented us with a completed report

* Groupings were as follows (interviews made in the county in italics): *Modoc* and Lassen; *Siskiyou* and Trinity; *Yolo*, Colusa and Glenn; *El Dorado*, Nevada, Placer and Alpine; *Calaveras* and Amador; *Tuolumne* and Mariposa; *Stanislaus* and Merced.

DO NOT WRITE IN THIS SPACE

Survey ORC 9-F (1M) —9X
Int. No. (2-4) _____
Resp. No. (5-8) _____
County of Residence (9-10) _____

ORC 9-F
March-April, 1949

Opinion Research Center

UNIVERSITY OF DENVER

1. How long have you lived in California?
   Less than a year (1948)....(11M) 1
   1 - 3 years (1945-47) 2
   4 - 6 years (1942-44) 3
   7 - 9 years (1939-41) 4
   10 years or more (before 1939)... 5

2. Did you do any fishing in California during the past year —1948?
   Yes 7
   No 8

IF "NO," SKIP TO QUESTION 19, PAGE 3.

3. Would you look at the kinds of fish listed on this card, and tell me whether or not you caught or fished for any of these in California during 1948? (HAND RESPONDENT CARD. CIRCLE AS MANY KINDS OF FISH AS HE MENTIONS.)

   No, none of them ..... (12M) s

   Steelhead trout 1
   Other trout 2
   Salmon (ocean) 3
   Salmon (river) 4
   Striped bass 5
   Black bass 6
   Crappie 7
   Sunfish 8
   Catfish 9
   Barracuda 0
   Abalone X
   Other ocean fish (specify) _____ V

IF RESPONDENT DID NOT CATCH OR FISH FOR ANY OF THE KINDS OF FISH LISTED, SKIP TO QUESTION 16, PAGE 3.

(READ THIS STATEMENT TO THE RESPONDENT VERBATIM BEFORE ASKING QUESTIONS 4 - 14):

Now (as our letter said) we are not interested in checking up on individual persons. We are just making a sample census to estimate the number and kind of fish caught in California last year. We find it's pretty hard for some people to remember all the details about where they went and what luck they had, so maybe that list you have and this map (HAND RESPONDENT MAP) will help you remember about your fishing trips. First, how about: (NAME FIRST KIND OF FISH MENTIONED BY RESPONDENT ON QUESTION 3.)

Questions 4 - 14: ASK QUESTIONS A - C BELOW FOR EACH KIND OF FISH MENTIONED BY RESPONDENT ON QUESTION 3, SUBSTITUTING KIND OF FISH FOR THE WORDS (STEELHEAD TROUT). RECORD THE ANSWERS FOR EACH TYPE IN THE PROPER SPACES ON THIS AND THE FOLLOWING TWO PAGES.

A. On how many different days, including parts of days, did you catch or fish for (steelhead trout) in California in 1948? (RECORD EXACT NUMBER OF DAYS.)

B. In what counties did you catch or fish for (steelhead trout)? (LIST EACH COUNTY ON A SEPARATE LINE.)

C. Did you catch any (steelhead trout) in (.....) County? How many? (REPEAT THIS QUESTION FOR EACH COUNTY FISHED IN. WRITE "0" FOR EACH COUNTY IN WHICH RESPONDENT FISHED BUT CAUGHT NOTHING.) This is very important, so take your time and think back.

	B. Counties Fished In	C. No. Caught In Each County	B. Counties Fished In	C. No. Caught In Each County	B. Counties Fished In	C. No. Caught In Each County
☐ 4. STEELHEAD TROUT (Over 12 inches)						
A. Total days caught or fished for: (13-14)						
LEAVE BLANK Total (15-16)						
☐ 5. OTHER TROUT						
A. Total days caught or fished for: (17-19)						
LEAVE BLANK Total (20-22)						
☐ 6. SALMON (caught or fish for in the ocean)						
A. Total days caught or fished for: (23-24)						
LEAVE BLANK Total (25-26)						

FIGURE 70. Portion of the 1948 personal interview ballot.

containing the information we had specified, plus additional material they thought we might find valuable. We then took over again and carried on the work outlined in the present report. It was frequently necessary for us to return to the original ORC interview reports to make minor adjustments of one sort or another. As a result, some of our figures differ slightly from those listed in the official ORC report.

The projection factor by which ORC figures have been multiplied to obtain state-wide estimates is $\frac{957,000}{1,250}$, which equals 765.6.

The original plan for evaluating nonresponse had been to compare the catch-report characteristics of the interviewed anglers who did and did not return their postal cards. However, as the program developed it became increasingly apparent that this was not the best approach, because of the small sample sizes involved. Only about 800 interviewees were sent cards. As few as ten percent of them fished for certain important varieties, and in all cases except trout the proportion was quite low. Further division into those who did and did not return cards gave samples of the order of 50 or less reports. The inadequacy of such small numbers in the present connection will be apparent from the sections which follow.

In order to increase the size of the samples the whole project was reoriented and an alternative approach was taken. The two surveys were treated as independent samples from the same universe,* and were compared on that basis. This made it possible to utilize all reports from both surveys, and sample sizes were therefore reasonably large.

Direct comparison of the various paired estimates from the two 1948 surveys can be used effectively to evaluate the influence of nonresponse upon final postal card estimates. The latter are based on the third of the sample which returned questionnaires, while the corresponding interview estimates are based on a similar, but smaller complete sample of anglers. In all other important respects the two survey samples are comparable, and differences between estimates from them can be attributed mainly to nonresponse.

A large variety of paired estimates from the two surveys are compared in the sections which follow. Few statistically significant differances were detected, and it is quite obvious that nonresponse had little influence on the final postal card estimates. Postal card respondents must actually be highly representative of angling licensees generally, at least insofar as answering our questionnaire is concerned.

COMPARISONS OF GENERAL CHARACTERISTICS OF PERSONAL INTERVIEW RESPONDENTS WHO DID AND DID NOT RETURN POSTAL CARDS

We were naturally very curious to learn all we could about any basic differences between anglers who return postal cards and those who do not. The best source of information on the subject is a series of comparisons made by ORC of the individuals in their interview sample who received cards, and who were subsequently interviewed.

Some of the more important comparisons of those who did and did not return their cards are outlined in Table 25. They indicate that postal card returns represent a surprisingly good random sample of California anglers. There is very little difference between the two groups as regards the general characteristics included in Table 25.

* The small overlap of about 250 individuals who appeared in both surveys is of no serious consequence since it amounted to only about 5 percent of the total postal card returns. It was impractical to separate this component, for a variety of reasons.

TABLE 25

General Comparisons of Licensees in the ORC Interview Sample Who Did and Did Not Return Postal Cards

	Percent of respondents who returned cards	Percent of respondents who did not return cards
TOTAL DAYS FISHED	* (244)	* (471)
1- 9 days	48	52
10-19 days	25	21
20-29 days	9	12
30 or more days	18	15
Totals	100	100
KINDS FISHED FOR	(245)	(473)
Steelhead trout	15	12
Other trout	62	46
Salmon (ocean)	6	3
Salmon (river)	10	11
Striped bass	31	30
Black bass	22	24
Crappie	19	19
Sunfish	14	13
Catfish	29	29
Barracuda	15	16
Abalone	9	6
Other ocean fish	41	39
None of them	†	2
Totals	273	250
REGION	(253)	(498)
San Francisco Bay region	32	28
Los Angeles region	43	39
San Diego region	3	6
Stockton-Bakersfield region	12	15
Sacramento-Redding region	8	9
Eureka region	2	3
Totals	100	100
CITY SIZE	(253)	(498)
Places under 2,500 population	21	27
Places of 2,500-9,999	19	17
Places of 10,000-24,999	14	15
Places of 25,000-99,999	20	16
Places of 100,000 and over	26	25
Totals	100	100
LENGTH OF RESIDENCE IN CALIFORNIA	(253)	(497)
Less than 3 years	7	9
4-6 years	6	7
7-9 years	7	7
10 years or more	80	77
Totals	100	100
PREVIOUS LICENSE	(253)	(498)
Had first license before 1948	86	82
Bought first license in 1948	14	18
Totals	100	100
HUNTING LICENSE	(252)	(497)
Had hunting license in 1948	32	36
Did not have hunting license	68	64
Totals	100	100
OCCUPATION	(252)	(497)
Professional, semiprofessional workers	14	7
Proprietors, managers, officials	13	13
Clerical, sales workers	15	10
Craftsmen, foremen (skilled labor)	20	22
Operatives, laborers (unskilled labor)	14	18
Service workers	4	7
Farmers, farm workers	5	9
Not classifiable (students, housewives, retired, etc.)	15	14
Totals	100	100

TABLE 25—Continued

General Comparisons of Licensees in the ORC Interview Sample Who Did and Did Not Return Postal Cards

	Percent of respondents who returned cards	Percent of respondents who did not return cards
SOCIO-ECONOMIC STATUS	(251)	(492)
Upper group	26	21
Middle group	64	64
Lower group	10	15
Totals	100	100
EDUCATION	(252)	(495)
Eighth grade or less	20	27
High school	49	53
College	31	20
Totals	100	100
SEX	(253)	(498)
Men	83	84
Women	17	16
Totals	100	100
AGE	(252)	(496)
16-29 years	14	20
30-39 years	34	29
40-49 years	23	26
50-59 years	17	14
60 years or more	12	11
Totals	100	100

* Numbers in parentheses in this table represent the number of cases in each group.
† Less than 0.5 percent.

COMPARISON OF GENERAL ESTIMATES OF NUMBERS OF ANGLERS FISHING AND DAYS FISHED

Both surveys indicated that about 95 percent of all licensees went angling. The slight difference between the two was not statistically significant.

Roughly 80 percent of all licensees caught fish of some kind during 1948. The difference between the paired values from the two surveys, shown in Table 26, is quite small. However, it can be considered statistically significant, since it was to be expected on the basis of chance only once in a hundred times. The discrepancy is believed to stem mainly from minor differences in the two questionnaires. The personal interview form had a catch-all question about fishing for marine species and a specific question about abalone. Neither was included on the postal cards. There is therefore a tendency for individuals who caught only marine fish or abalone to appear as successful anglers on an interview but as unsuccessful ones on a postal card return. As a matter of fact, the discrepancy would have been even greater had not some postal card respondents noted on their returns that they had caught only ocean fish, even though there was no space for such information. The personal interview estimate of 83.6 percent successful anglers is probably the more reliable of the two, everything considered. However, even it excludes licensees who took only clams. Such individuals may be fairly numerous, judging from comments on some of the postal card returns.

TABLE 26

Projected General Angler Totals From the Two Surveys

	Postal card survey	Personal interview survey
Number of licensees who fished	905,000	912,600
Percent of all licensees	94.6	95.4
Number of licensees not fishing	51,900	44,400
Percent of all licensees	5.4	4.6
Number of successful anglers	728,000	800,800
Percent of those fishing	80.5	87.7
Percent of all licensees	76.1	83.6
Number of unsuccessful anglers	* 176,000	111,800
Percent of those fishing	19.5	12.3
Percent of all licensees	18.4	11.7
Total fishing days	13,940,000	15,390,000
Average days for all licensees	14.6	16.1
Average days for those fishing	15.4	16.9

* Includes the small group (2.1% of the total sample) which caught nothing but failed to state if they fished.

Another type of estimate which is of great interest from a fisheries management standpoint is the total amount of fishing going on during a year. An estimate of 13,940,000 days during 1948 was obtained from the postal card survey, and the corresponding ORC figure was 15,390,000 days. In terms of the average number of days per angler these represent 15.4 and 16.9 days, respectively. For any practical consideration, the difference is negligible, and it can therefore be concluded that nonresponse had very little influence upon the postal card estimate. It is statistically significant, however, since it was not to be expected by chance oftener than three times out of a hundred. In general, individuals tended to report a little more fully in an interview than on a postal card, which is not surprising. This could readily explain the slight difference noted.

STATISTICAL COMPARISONS AND FIDUCIAL LIMITS OF MEAN CATCH ESTIMATES

Catches of the eight kinds of fish covered in the 1948 survey have been compared in considerable detail. All the individual catch reports were combined into paired frequency distributions. Four of these are graphed in the accompanying figures. All 16 curves were strongly J-shaped.* Zero catches have been omitted throughout, because they are not obtainable from postal card returns.

The general uniformity of the catch reports from the two surveys is actually quite remarkable, everything considered. Postal card nonresponse apparently produced little or no distortion.

A statistical evaluation of the differences between the pairs of catch frequencies for the eight species has been made and the results are summarized in Table 27. None of the differences between the two mean

* Statisticians have assured us that, with the sample sizes involved, fiducial limit procedures based on the normal curve are applicable to these data.

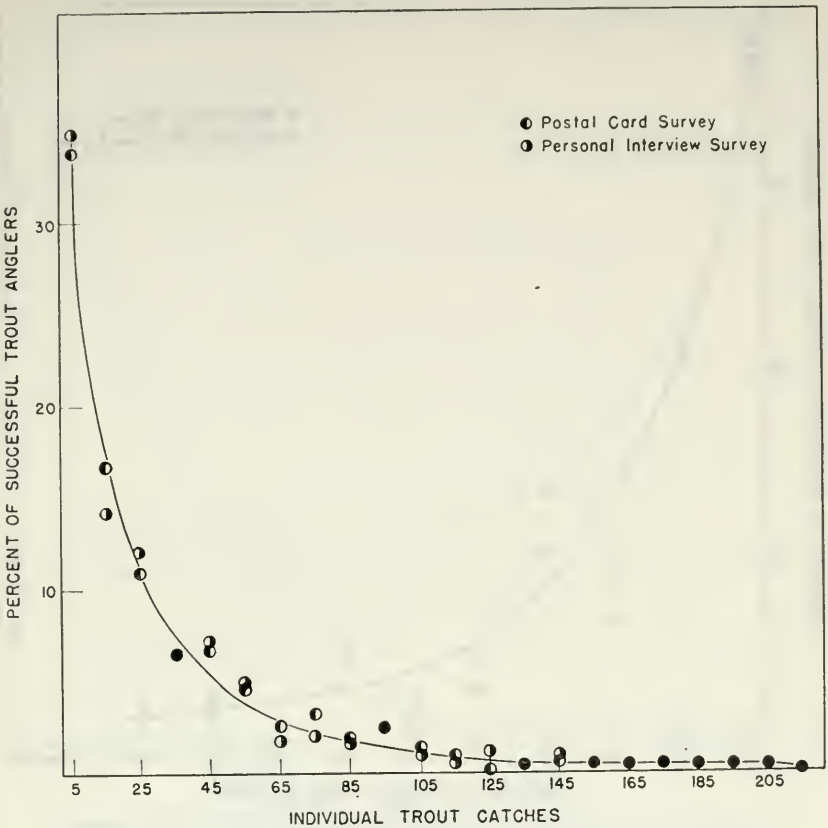

FIGURE 71. Frequencies of trout anglers by number of fish caught.

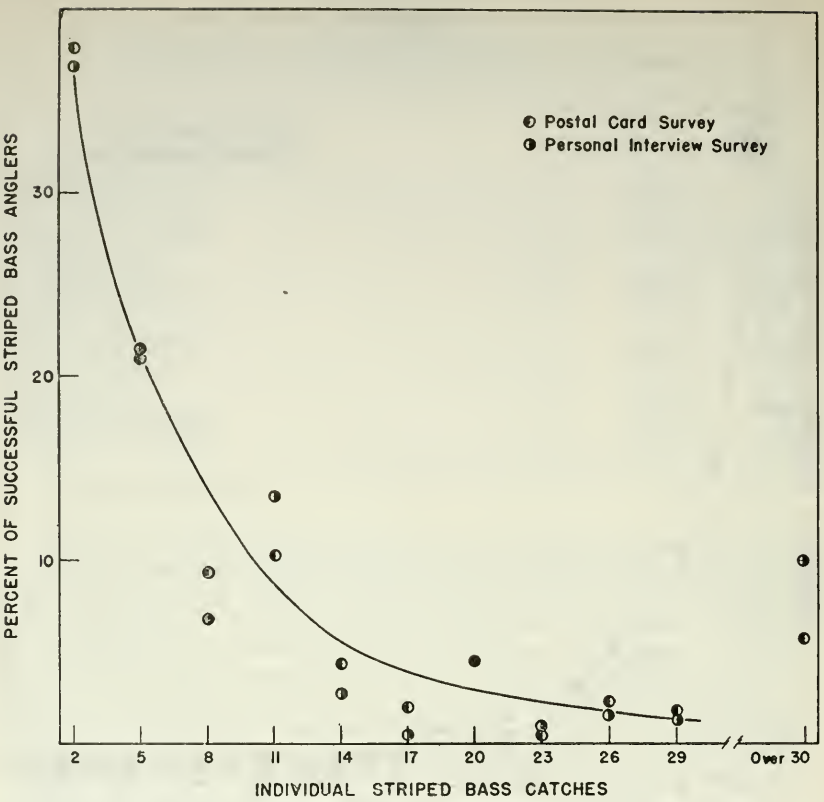

FIGURE 72. Frequencies of striped bass anglers by number of fish caught.

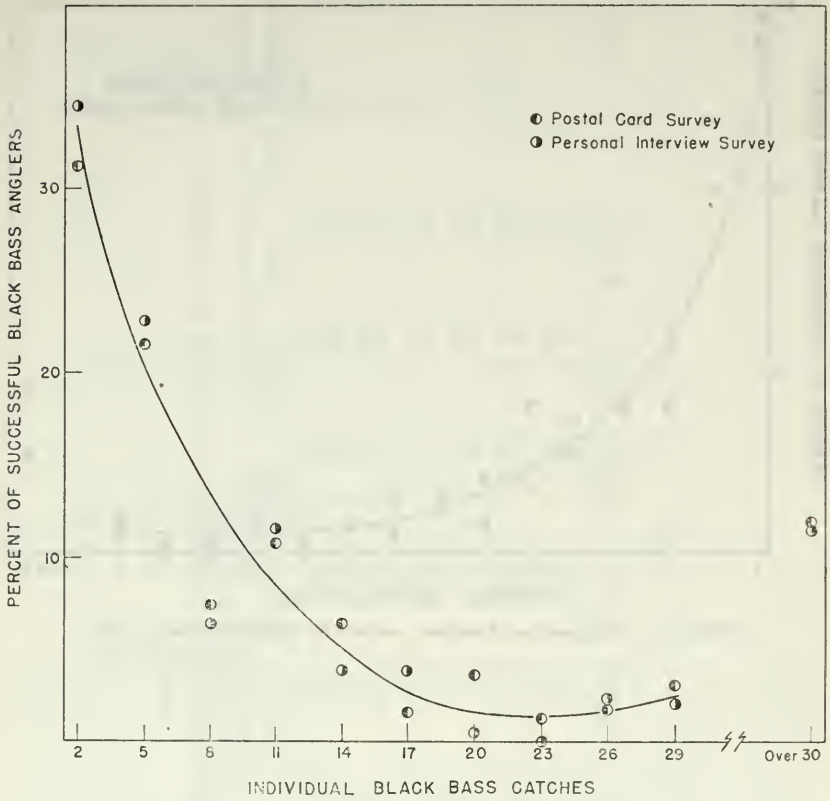

FIGURE 73. Frequencies of black bass anglers by number of fish caught.

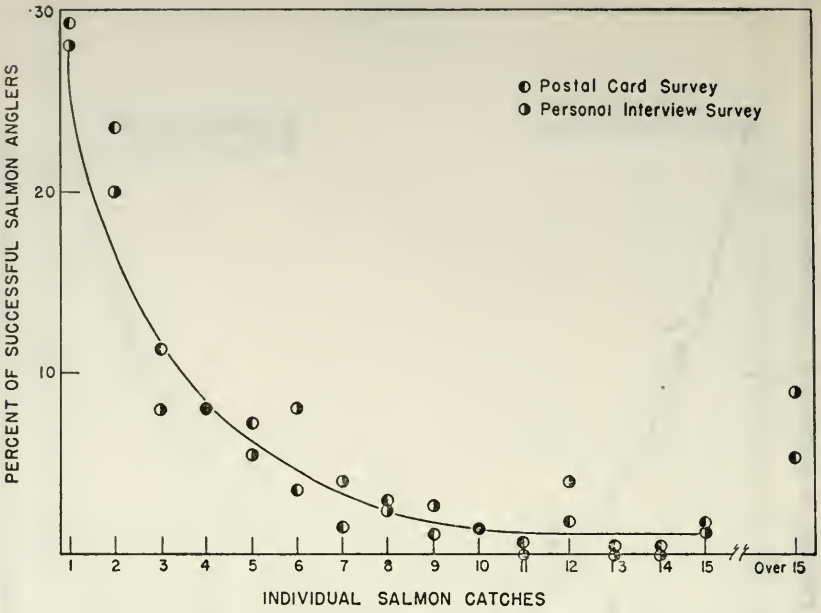

FIGURE 74. Frequencies of salmon anglers by number of fish caught.

TABLE 27

Summary of Statistical Data for the Catch Frequency Distributions From the Two Surveys, Not Including Zero Catches

		Trout	Striped bass	Black bass	Crappie	Sunfish	Catfish	Salmon	Barracuda
Number of catch reports for species indicated	Card	2,493	967	772	695	708	1,091	390	564
	ORC	525	224	188	237	136	289	75	134
Largest catch	Card	920	173	235	350	1,000	900	50	450
	ORC	841	160	200	200	300	800	60	300
Mean (average) catch	Card	44.5	10.3	14.7	23.8	41.0	30.7	4.9	15.4
	ORC	48.0	12.7	15.6	27.2	44.4	39.8	6.5	16.3
Median catch	Card	20	5	6	12	20	15	2	8
	ORC	20	5	6	15	20	15	3	7
Standard deviation	Card	71.41	16.06	26.51	34.00	67.60	54.35	5.98	31.37
	ORC	87.10	20.74	29.41	38.6	58.26	85.41	11.09	31.39
Standard error of mean	Card	1.43	0.52	0.96	1.29	2.54	1.71	0.31	1.32
	ORC	3.81	1.38	2.14	2.51	5.00	5.05	1.28	2.71
Fiducial limits of the mean at the 5% level	Card	41.7-47.3	9.3-11.3	12.8-16.6	21.3-26.3	35.9-46.1	27.4-34.0	4.3- 5.5	12.8-18 0
	ORC	40.5-55.5	10.0-15.4	11.5-19.7	22.3-32.1	34.6-54.2	29.9-49.7	4.0- 9.0	11.0-21.6
Significant difference between the two means?	No	No	No	No	No	No	No	No	No

annual catch estimates for any species is statistically significant. The other material in Table 27 is primarily for reference purposes.

A matter of considerable basic interest in dealing with surveys of this sort is the statistical reliability of the various estimates obtained. In the cases of these mean catches it is a simple matter to derive a standard error (Waugh, 1943, p. 235). This figure indicates the range over which such a mean can be expected to vary as a result of chance differences in sampling. To illustrate with an example, the mean trout catch from the cards was 44.5 trout. Its standard error was 1.43 trout. Nineteen times out of twenty such a mean should fall within a range extending roughly two standard errors either way from the actual value obtained. Expressed differently, if 20 similar postal card surveys had been made, 19 of the 20 mean trout catch figures obtained could reasonably have been expected to fall between 41.7 and 47.3. These latter figures represent the so-called fiducial limits, in this instance at the 5 percent level. Figure 75 is intended to clarify this concept further. It also provides a simple, graphic picture of the whole array of 16 mean catch figures obtained from the two 1948 surveys. The bars with solid, black bases represent the postal card mean catches. Those with hatched bases represent the corresponding ORC figures. There is a pair of such bars for each species. The broken line across the center of the stippled part of each bar is the actual mean obtained. The stippled section is bounded by the fiducial limits of this mean. In effect, the stippled section indicates the range of values over which the actual mean might very well have occurred as a result of chance differences in sampling.

Figure 75 illustrates our statement that the differences between the various pairs of means are not significant. This is suggested at once from the fact that the stippled sections of corresponding bars overlap consistently. The relatively shorter length of the stippled sections of the postal card bars is an expression of the larger sample sizes involved.

Before leaving the subject of mean catches, let us examine briefly a similar comparison of the mean catches of actual ORC respondents who did and did not return postal cards. The pertinent data are outlined in Table 28. It is obvious at a glance that the differences between these

TABLE 28

Comparison of Catch Characteristics of ORC Respondents Who Did and Did Not Return Postal Cards

		Trout	Black bass	Crappie	Sunfish	Catfish	Barracuda
Number of catch reports	Did	124	43	38	28	61	25
	Did not	165	74	79	53	115	59
Mean catch	Did	38.7	14.5	28.5	47.8	41.1	11.4
	Did not	30.4	9.5	20.7	31.6	26.8	12.0
Standard deviation *		87.1	29.4	38.6	58.3	85.4	31.4
Standard error of the mean	Did	7.7	4.4	6.3	11.2	10.9	6.4
	Did not	6.8	3.5	4.4	8.1	8.0	4.1
Significant difference?		No	No	No	No	No	No

* ORC standard deviations from the preceding table were used.

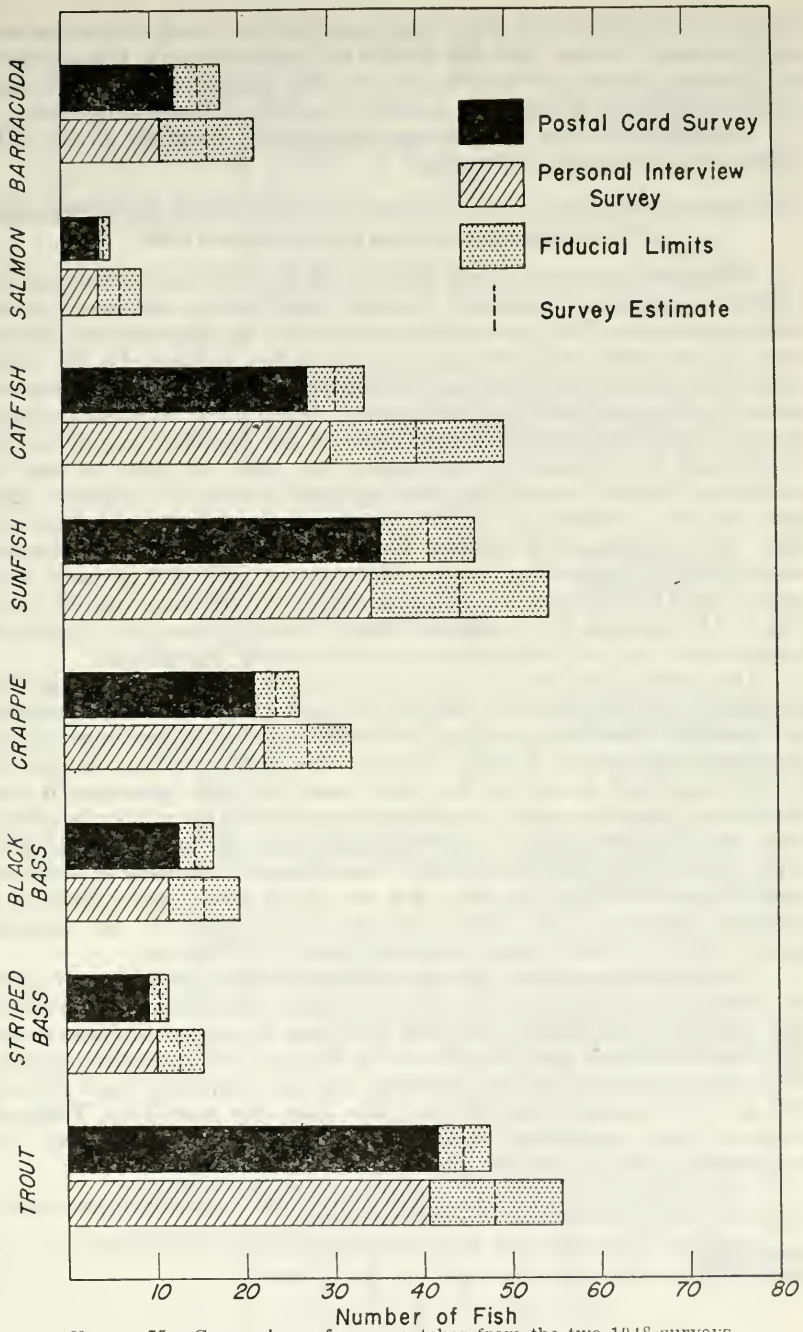

FIGURE 75. Comparison of mean catches from the two 1948 surveys.

means are not significant. They were nevertheless tested, to remove any possible doubt. Striped bass and salmon are not included in this comparison, because certain peculiarities of the ORC sample made direct comparison impossible without an excessive amount of hand-tabulating.

It is apparent that nonresponse had little or no effect on the 1948 postal card mean catch estimates.

STATISTICAL COMPARISONS AND FIDUCIAL LIMITS OF PERCENTAGES OF LICENSEES ANGLING FOR VARIOUS FISH

Estimates of percentages of licensees angling for various fish require a different statistical treatment than the mean catches compared in the preceding section. The trout estimates will serve to illustrate the method used in comparing such estimates from the two surveys. Of the 5,751 postal card respondents, 43.3 percent reported catches of trout.* Assuming accurate reports and a random sample, the numbers involved are large enough to give this figure high reliability. It is a relatively simple matter to calculate its standard error,† which can, then, in turn be used to determine fiducial limits. Thus, the standard error of the postal card figure of 43.3 percent successful trout anglers is found to be 0.65 percent. The corresponding fiducial limits within which this percentage should fall 19 times of of 20 are 42.0 percent and 44.6 percent. Corresponding ORC figures are 42.0 percent for the estimate and 39.3 percent to 44.7 percent for its fiducial limits. The difference of 1.3 percent between the two trout estimates is not statistically significant.

The paired percentages from the two surveys of successful anglers fishing for all eight kinds of fish are outlined in Table 29 and graphed in Figure 76. Much the same general situation exists as was noted in the preceding comparison of mean catches. The difference was not statistically significant in six of the eight cases. In two instances it was significant, although small. One of these was catfish, for which the difference was 4 percent, which is actually negligible for all practical purposes. It could very well have arisen from a greater tendency to forget or ignore these relatively unprized fish on postal card reports than in a personal interview. The other discrepancy occurred in the crappie figures, which revealed about the same degree of difference.

Everything considered, these two discrepancies need give no cause for concern, particularly since one significant difference could reasonably have been expected on the basis of chance in a group as large as the 16 pairs which have been considered in this and the preceding section. The close agreement between estimates for the more important species, such as trout, striped bass, and black bass, was very gratifying. Taken as a group, these comparisons indicate that postal card nonresponse can be ignored in this connection also.

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* It is necessary to use only successful anglers in these comparisons because unsuccessful ones cannot be estimated from the postal cards.

† $SE = \sqrt{\frac{PQ}{N}}$, in which N is the total number of anglers in the sample, P is the number who caught a given kind of fish, and Q is N minus P.

TABLE 29

Statistical Comparison of Percentages of Anglers in the Two Samples Fishing Successfully for Various Fish

		Trout	Striped bass	Black bass	Crappie	Sunfish	Catfish	Salmon	Barracuda
Number of successful anglers	Card*	2,493	967	772	695	708	1,091	390	564
	ORC†	525	224	188	200	136	286	75	134
Such anglers as percent of total sample	Card	43.3	16.8	13.4	12.1	12.3	19.0	6.8	9.8
	ORC	42.0	17.9	15.0	16.0	10.9	22.8	6.0	10.7
Standard errors of these percents	Card	0.65	0.50	0.45	0.43	0.43	0.52	0.33	0.39
	ORC	1.40	1.08	1.01	1.04	0.85	1.19	0.63	0.85
Fiducial limits at 5% level	Card	42.0-44.6	15.8-17.8	12.5-14.3	11.3-12.9	11.4-13.2	18-20	6.2- 7.4	9.0-10.6
	ORC	39.3-44.7	15.8-20.0	13.0-17.0	14.0-18.0	9.2-12.6	21.6-23.0	4.8- 7.2	9.1-12.3
Significant difference between the percents?		No	No	No	Yes	No	Yes	No	No

* Total sample (N) = 5,751.
† Total sample (N) = 1,250.

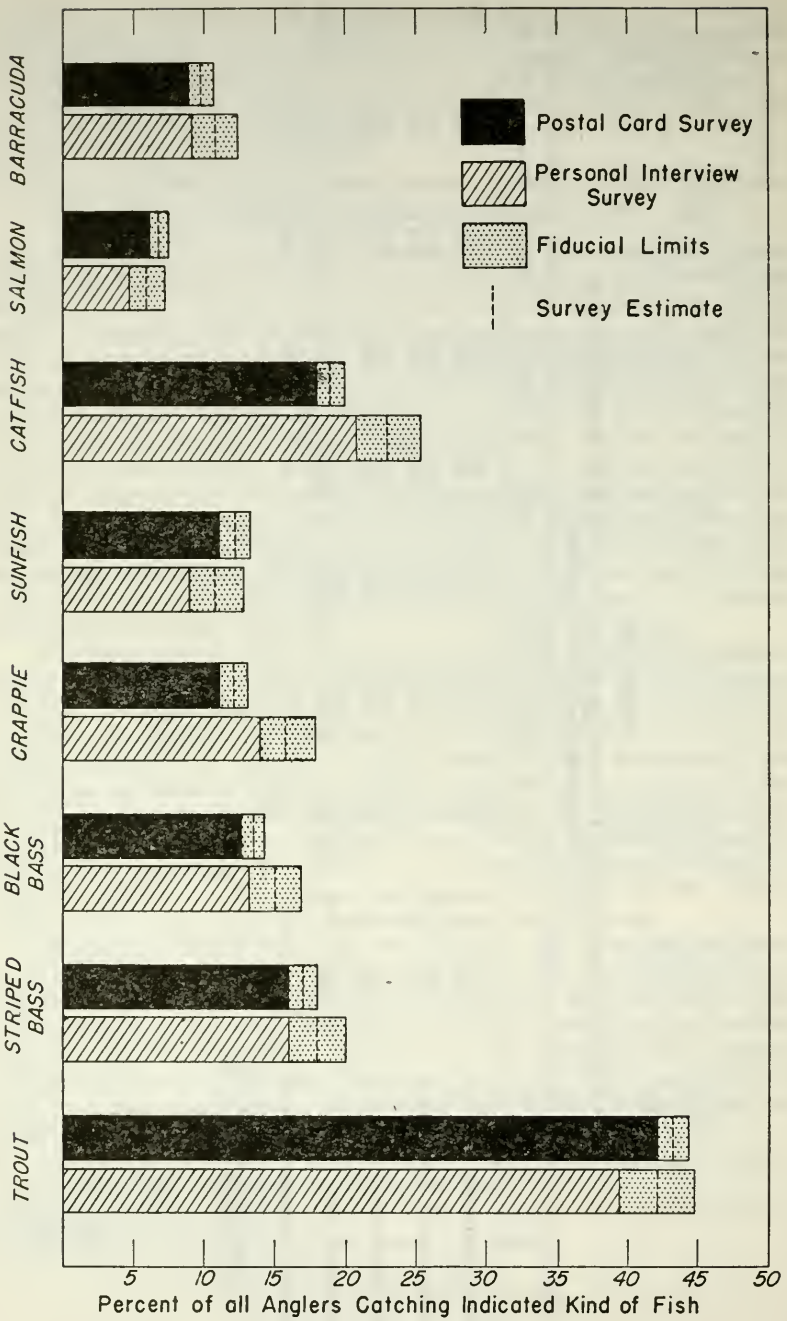

FIGURE 76. Comparison of percentages of anglers in the two samples fishing successfully for various fish.

STATISTICAL COMPARISONS AND FIDUCIAL LIMITS OF TOTAL CATCH ESTIMATES

In effect, total catch estimates from postal cards surveys are products of a mean catch estimate and an estimate of the number of anglers who caught the fish in question. To illustrate with an example, the 1948 survey indicated that 43.3 percent of all angling licensees were successful trout anglers with an average catch of 44.5 trout. In other words, 415,000 anglers averaged 44.5 trout for a total state-wide catch of 18,400,000.

Standard errors and fiducial limits of mean catches and numbers of anglers have been discussed in the preceding sections. The same concepts are, of course, applicable to their products, but the statistics are somewhat more complicated. We are indebted to Mr. Terry Jeeves of the Statistical Laboratory of the University of California at Berkely and to Mr. Austin A. Hasel of the U. S. Forest Service for locating a suitable method for dealing with this problem (Aroian, 1947; Craig, 1936; Schumacher and Chapman, 1948).

If X and Y are normally distributed random variables with means m_z and m_y, respectively, and variances σ^2_x and σ^2_y, respectively, and they are uncorrelated, then the product $Z=XY$ has mean

$$m_z=m_xm_y$$

and variance

$$\sigma_z^2=m_x^2\sigma_y^2+ m_y^2\sigma_x^2+ \sigma_x^2\sigma_y^2$$

The standard error of the mean is, of course, simply the square root of this variance. This formula has been applied to our data with the results outlined in Table 30, which shows the total catch figure for each species from both surveys, together with the corresponding standard

TABLE 30

Statistical Comparison of Total Catch Estimates From the 1948 Surveys

		Total catch	Standard error	Fiducial limits	Difference in total catch estimates	Statistically significant difference
Trout	Card	18,400,000	635,000	17,200,000-19,600,000		
	ORC	19,400,000	1,660,000	16,100,000-22,600,000	1,000,000	No
Striped bass	Card	1,650,000	97,000	1,460,000- 1,840,000		
	ORC	2,160,000	270,000	1,630,000- 2,690,000	510,000	No
Black bass	Card	1,890,000	138,000	1,620,000- 2,160,000		
	ORC	2,250,000	342,000	1,580,000- 2,920,000	360,000	No
Crappie	Card	2,760,000	178,000	2,410,000- 3,110,000		
	ORC	4,160,000	470,000	3,240,000- 5,080,000	1,400,000	Yes
Sunfish	Card	4,820,000	344,000	4,145,000- 5,500,000		
	ORC	4,625,000	631,000	3,390,000- 5,865,000	195,000	No
Catfish	Card	5,560,000	347,000	4,880,000- 6,240,000		
	ORC	8,719,000	1,190,000	6,390,000-11,049,000	3,159,000	Yes
Salmon	Card	321,000	25,400	271,000- 371,000		
	ORC	395,000	82,800	233,000- 557,000	74,000	No
Barracuda	Card	1,440,000	137,000	1,170,000- 1,710,000		
	ORC	1,900,000	307,000	1,300,000- 2,500,000	460,000	No

errors and fiducial limits. The difference between the paired total catch estimates from the two surveys was not statistically significant in six cases. It was significant in the case of crappie and catfish, which is not surprising, in view of the significant difference in the estimated numbers of anglers for these species, already discussed. Again, it is quite obvious that nonresponse had little effect upon these total catch figures.

The value of these standard error determinations is considerable. In the future they will enable us to compare survey results obtained in different years more critically and to determine whether or not the differences which occur from year to year can be attributed to sampling errors.

COMPARISON OF NUMBERS OF ANGLERS FISHING FOR TROUT IN DIFFERENT PARTS OF CALIFORNIA

Knowledge of the geographical distribution of trout fishing effort in California is important in connection with stocking policies and other phases of trout management. It is therefore desirable to know what influence, if any, nonresponse has upon postal card estimates of the regional distribution of trout angling, and a comparison of the two surveys is of interest in this connection.

Very small totals result when the 525 ORC respondents who caught trout are subdivided according to the counties in which they caught trout. The 58 California counties were therefore combined into eight larger areas to increase samples to a reasonable size. Areas used were the eight fresh-water fisheries management districts of the State, detailed in Appendix 1. A Chi-square test (Edwards, 1946, p. 250) was made of the hypothesis that the relative numbers of trout anglers in the two surveys who fished in the various districts represented two random samples from the same universe. Chi-square was found to be 11.45 which was not statistically significant for seven degrees of freedom. Differences as great as those obtained, shown in Table 31, were to be expected by chance oftener than once in 20 times. Nonresponse therefore did not significantly alter the general picture of regional fishing pressures upon trout obtained from the postal cards.

TABLE 31

Numbers of Anglers Catching Trout In Eight Management Districts

Management district	Postal card survey		Personal interview survey	
	Number	Percent	Number	Percent
1. Mt. Shasta	223	7.8	56	8.6
2. Mt. Lassen	301	10.5	70	10.7
3. Tahoe	440	15.3	105	16.1
4. Central	60	2.1	17	2.6
5. Coast	414	14.4	104	15.9
6. San Joaquin	412	14.3	104	15.9
7. Mt. Whitney	515	17.9	84	12.9
8. Southern	503	17.5	114	17.4
Totals	*2,868		*654	

* This exceeds the actual number of successful trout anglers because some fished in more than one district.

COMPARISON OF TROUT ANGLER MIGRATION PATTERNS

The Division of Fish and Game attempts to allot expensive hatchery-reared trout to different sections of the State in such a way so as to provide an equitable distribution of these fish among the general angling public. Information about trout angler migrations obtained from the postal card surveys helps make this possible. It is therefore important to know how much distortion nonresponse introduces into the patterns of angler migration revealed by the postal card surveys. A detailed comparison of the trout angler migrations revealed by the two 1948 surveys has been made. The fishing and residence areas used were the ones already referred to and outlined in the appendix. The 48 paired estimates of the numbers of anglers who lived in a given residence area and caught trout in a given management district have been plotted in the form of a scattergram in Figure 77. A few items near the origin have been omitted. The agreement is close. The correlation coefficient is 0.98. The equation for the least squares regression line (Waugh, 1943, p. 385), shown in the figure, is:

$$Y = 1.05 + 0.2105X.$$

Interestingly enough, the figure of 0.2105, which is the slope of this line, corresponds closely to the ratio $\frac{\text{number of interviewees}}{\text{number of postal card respondents}}$, which is 0.217. It will also be noted that the origin is very close to zero. The implication is that the paired numbers in the various categories are simply proportional to the parent sample sizes involved. Nonre-

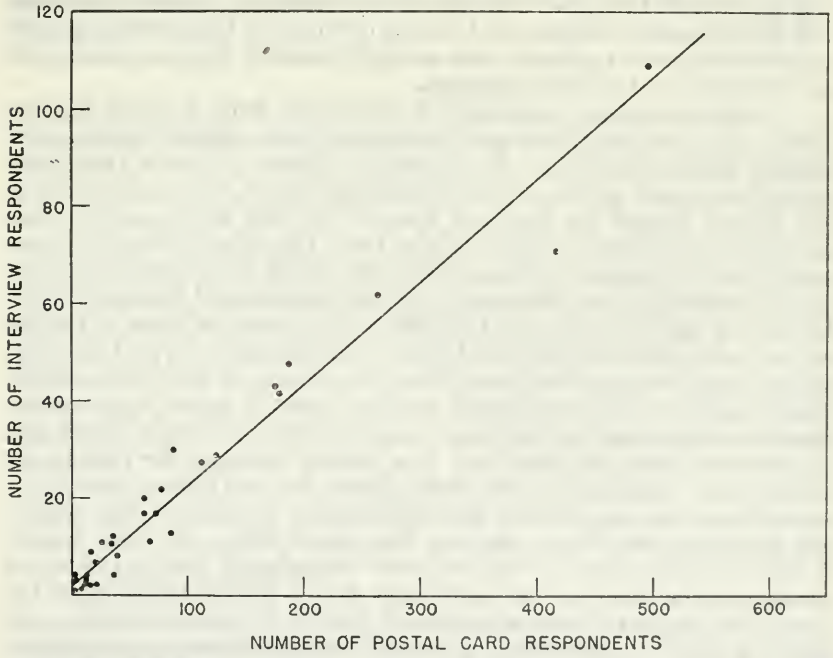

FIGURE 77. Scattergram of paired trout-angler migrations revealed by the two surveys.

sponse cannot have introduced any appreciable distortion into the postal card estimates, since they agree so closely with those from the ORC survey.

THE VALIDITY OF THE INDIVIDUAL POSTAL CARD REPORTS

The 1948 survey had the primary objective of evaluating nonresponse. It accomplished this very well, and we can now feel safe in assuming that this factor has little influence on postal card estimates. The second possible major source of error in these surveys is the questionable accuracy of the individual reports. It is another problem entirely, and one which is less readily attacked. A limited amount of information about it was obtained as a by-product of the 1948 survey, but before taking it up it will be well to discuss certain rather general aspects of the problem.

One fairly obvious way to evaluate the accuracy of angler reports as a group is to equate a postal card estimate to a comparable figure of known accuracy from another source. In the case of angling, this is usually easier said than done. It can be more readily accomplished in the case of hunting, and some valuable comparisons of pheasant kills on heavily controlled areas with comparable estimates for the same areas derived from postal cards have recently been made in California. These will be discussed by H. Hjersman in a later report.

Another approach to the problem would be to obtain accurate records for a random sample of licensees, without their knowledge, and to compare them with the reports that these same individuals made in the usual way at the end of the year. Valuable as this would be, it seems improbable that a state agency such as the Division of Fish and Game would be able to undertake such a project, and we shall probably have to concentrate our attention on the other approach.

A serious attempt was made in connection with the 1948 angling survey to equate the postal card barracuda catch estimate with a comparable figure obtained by the Bureau of Marine Fisheries from their party boat record program, with interesting results. We are indebted to Mr. Robert Collyer for the final figure of 413,000 sport-caught barracuda taken in Southern California in 1948. He estimates that it represents from 50 percent to 80 percent of the actual total California sport catch. Assuming it was 50 percent, the total catch would become 826,000. Our postal card estimate was 1,440,000 with a standard error of 137,000 and a lower fiducial limit of 1,170,000. This brings the two barracuda figures quite close together, everything considered. It would actually be unreasonable to expect complete accuracy from a postal card survey. Similar comparisons in California and elsewhere involving ducks and pheasants suggest that there may be a general tendency for postal card estimates for these birds to be about double the true figure, although it would be premature to draw final conclusions. In general, fish catches are scattered over longer seasons than game kills, and they usually involve animals which are less of a prize individually than, let us say, a pheasant. It is therefore not improbable that a general tendency on the part of an angler to forget a portion of the fish he caught during a year would tend to counterbalance a normal human tendency to exaggerate angling success. Nonreporting by children under license age would act in the same direction. Barracuda, being a rather large and impressive

fish, could reasonably be expected to be intermediate between fish such as trout and game such as pheasants. The degree of exaggeration of the postal card figure for barracuda in 1948, compared with the party boat figure, suggests that this may indeed be the case.

The 1948 survey also provided some interesting information about the ability of individual anglers to remember their catches. It was possible to compare a sizable number of double reports from the same individuals made on separate occasions a few weeks apart. It will be recalled that two-thirds of the anglers who were interviewed in 1948 received postal card figure for barracuda in 1948, compared with the party boat general, there was reasonably good correlation between the two reports for the same individual, although it was less than had been anticipated and there were some surprising discrepancies. The correlation coefficients for the eight kinds of fish are outlined in Table 32, and the trout reports are shown in the scattergram in Figure 78, which has been included to

TABLE 32

Comparison of Double Reports by the Same Individual on Two Occasions

	Number of double reports	Mean catch from first reports on postal cards	Mean catch from second reports on personal interview	Coefficient of correlation
Trout	128	41.9	52.4	0.86
Striped bass	46	11.6	10.9	0.82
Black bass	46	9.1	12.2	0.83
Crappie	41	15.0	26.6	0.91
Sunfish	38	20.3	39.6	0.40
Catfish	64	28.2	43.0	0.93
Salmon	18	3.3	4.7	0.98
Barracuda	26	12.5	14.3	0.75

serve as an example. In spite of a tendency for the number of fish reported to differ somewhat on the two reports, there was nevertheless no consistent bias of any importance one way or the other, and the mean catches of the two series of reports tended to be fairly close. The different fish gave quite dissimilar results, with a near-perfect correlation for salmon and almost no correlation for sunfish. Others were intermediate. The intrinsic value of the individual fish is obviously an important factor in this connection, which is not too surprising. The further fact that many individuals confuse sunfish with other fish should be kept in mind. In certain cases it appeared that sunfish were reported as such on one report and as something entirely different on another. Another reason for part of the lack of correlation between these paired reports appears to have been a tendency for certain husbands who caught a lot of fish to fill in the postal cards mailed to their wives, who caught few. The interviewer would then obtain an entirely different set of figures from the wife. This factor cannot be evaluated accurately, but it undoubtedly had its effect in reducing correlations. It would, of course, also tend toward exaggeration of postal card estimates.

The whole matter of the validity of the individual catch reports requires a great deal more attention. Now that the factor of nonresponse has been taken care of, it will be possible to concentrate efforts on this second problem.

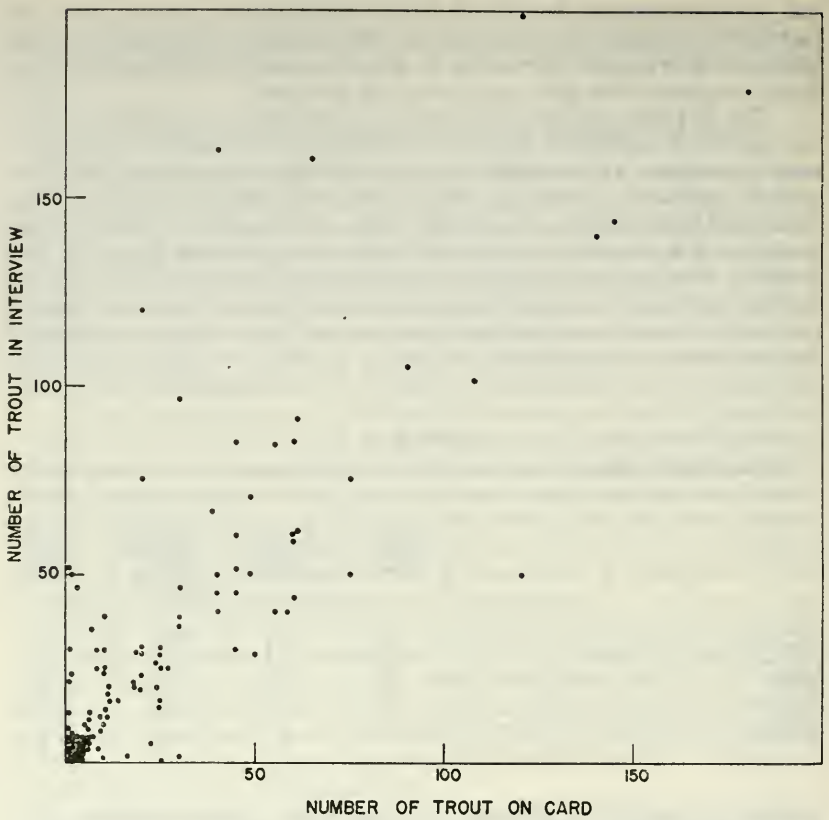

FIGURE 78. Scattergram of trout catches reported by the same individuals at different times.

SUMMARY

California angling catch records have been obtained from state-wide postal card surveys since 1936. They provide annual estimates of total catches, average catches, and numbers of anglers fishing for the important fresh-water and anadromous fishes. These estimates are outlined in detail in a series of tables and charts in Part I. The county distribution of 1948 catches is also described. Standard errors and fiducial limits of the three main types of estimates obtained from the surveys are discussed in Part II.

Over-all angling pressure in California has increased fivefold since 1935. Marked increases in angling have occurred for each of the fishes covered in the surveys. The average annual catch has declined appreciably for all but sunfish. In most cases the total annual catch has increased somewhat during this period of rapidly increasing angling pressure.

A special personal interview survey was conducted in 1948 to evaluate the influence of postal card nonresponse upon postal card survey estimates. No important warping of the estimates of mean catches, numbers

of anglers, and total catches was detectable. Nonresponse is not an important source of error in these California angling catch estimates. It was also found to produce little or no distortion in the general picture of trout angler migrations revealed by the postal card surveys.

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APPENDIX I

COUNTIES IN THE MANAGEMENT DISTRICT *

District 1

25 Modoc
45 Shasta (in part) †
47 Siskiyou
53 Trinity

District 2

4 Butte
11 Glenn
18 Lassen
32 Plumas
45 Shasta (in part) †
52 Tehama

District 3

2 Alpine
3 Amador
5 Calaveras
9 El Dorado
29 Nevada
31 Placer
46 Sierra
55 Tuolumne

District 4

6 Colusa
7 Contra Costa
24 Merced
34 Sacramento
38 San Francisco
39 San Joaquin
48 Solano
50 Stanislaus
51 Sutter
57 Yolo
58 Yuba

* Except Shasta County, catches from all counties falling in two districts have been thrown into the district in which the trout were most apt to have been caught. In most cases the resulting discrepancy will be negligible.

† Half of the Shasta County catch was included in District 1 and half in District 2, in all break-downs and totals.

District 5

1 Alameda
8 Del Norte
12 Humboldt
17 Lake
21 Marin
23 Mendocino
27 Monterey
28 Napa
35 San Benito
41 San Mateo
43 Santa Clara
44 Santa Cruz
49 Sonoma

District 6

10 Fresno
15 Kern
16 Kings
20 Madera
22 Mariposa
54 Tulare

District 7

14 Inyo
26 Mono

District 8

13 Imperial
19 Los Angeles
30 Orange
33 Riverside
36 San Bernardino
37 San Diego
40 San Luis Obispo
42 Santa Barbara
56 Ventura

APPENDIX II

COUNTIES IN THE RESIDENCE AREAS

Southern California

13 Imperial
19 Los Angeles
30 Orange
33 Riverside
36 San Bernardino
37 San Diego
40 San Luis Obispo
42 Santa Barbara
56 Ventura

San Francisco

1 Alameda
7 Contra Costa
21 Marin
28 Napa
38 San Francisco
41 San Mateo
43 Santa Clara
44 Santa Cruz
48 Solano
49 Sonoma

Sacramento

4 Butte
6 Colusa
9 El Dorado
11 Glenn
17 Lake
29 Nevada
31 Placer
34 Sacramento
46 Sierra
51 Sutter
57 Yolo
58 Yuba

South Central California

10 Fresno
14 Inyo
15 Kern
16 Kings
20 Madera
26 Mono
27 Monterey
35 San Benito
54 Tulare

San Joaquin

2 Alpine
3 Amador
5 Calaveras
22 Mariposa
24 Merced
39 San Joaquin
50 Stanislaus
55 Tuolumne

Northern California

18 Lassen
25 Modoc
32 Plumas
45 Shasta
47 Siskiyou
52 Tehama
53 Trinity
8 Del Norte
12 Humboldt
23 Mendocino

FOOD HABITS OF A CALIFORNIA DEER HERD *

By Carol M. Ferrel and Howard R. Leach
Bureau of Game Conservation
California Division of Fish and Game

INTRODUCTION

The migratory herd of mule deer *(Odocoileus hemionus californicus)* occupying the winter deer range along the west slope of the Sierra Nevada in Tuolumne County between elevations of 1,500 and 4,000 feet is commonly known as the Jawbone deer herd. During the summer months, this herd of deer moves into a much larger summer range area extending from the 4,000-foot elevation upward to the Sierran crest at elevations of 10,000 feet.

The Jawbone deer herd is thus typical of the several deer herds which occupy the west slopes of the Sierra, having seasonal altitudinal migrations and highly restricted winter ranges with summer ranges several times the area of this critical winter range. With deer numbers exceeding the carrying capacity on many deer ranges in California, especially during the critical winter months, the character and abundance of their food supply becomes of increasing importance in the successful management of both the deer and the range which must support them.

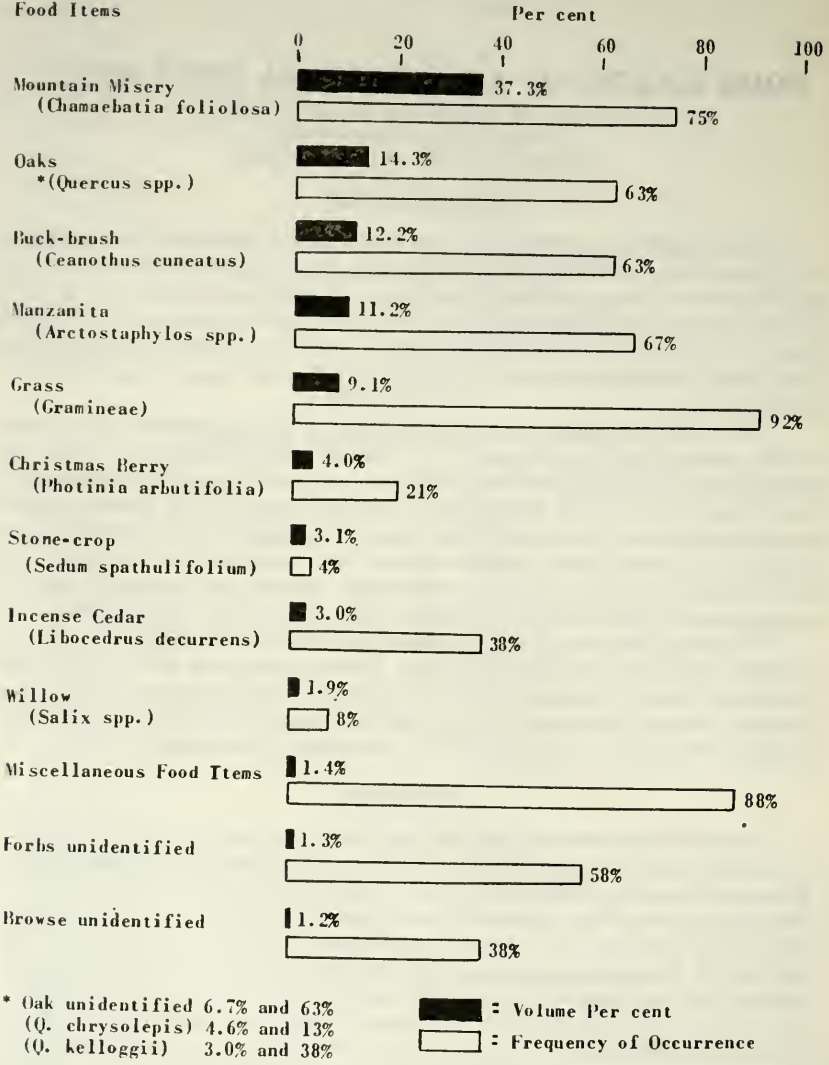
The data presented here represent the results of analyses of stomach samples taken from a total of 40 deer. Twenty-four deer were taken from the winter range (November-May) and 16 from the summer range (June-October) during the years 1947 to 1949 inclusive. Collections from every month of the year are represented in the material examined.

METHODS

Stomach samples were taken from deer which were collected by shooting under permit granted by the California Fish and Game Commission. These were supplemented by stomach samples collected by hunters during the regular open deer season. Stomach samples were wrapped in cheesecloth and preserved in 5 percent formaldehyde solution and taken to the laboratory for analysis. In the food habits laboratory the material was washed and analyzed while wet. The aggregate percentage method (Martin, A. C., R. H. Gensch and C. P. Brown, 1946) was used in summarizing results. Identifications were made macroscopically or with the aid of a dissecting microscope. Comparison with identified field collections of deer food plants from the area under study resulted in positive identification of virtually all of the food items encountered.

* Funds for this work were provided by federal aid in Wildlife Restoration Act Project California 25R. Cooperation and assistance was received from Projects California 28R and 35R. Submitted for publication March 1950.

Principal Foods in the Diet of the Jawbone Deer on their Winter Range



* Oak unidentified 6.7% and 63%
(Q. chrysolepis) 4.6% and 13%
(Q. kelloggii) 3.0% and 38%

= Volume Per cent
= Frequency of Occurrence

FIGURE 79

Principal Food Items in the Diet of the Jawbone Deer on their Summer Range

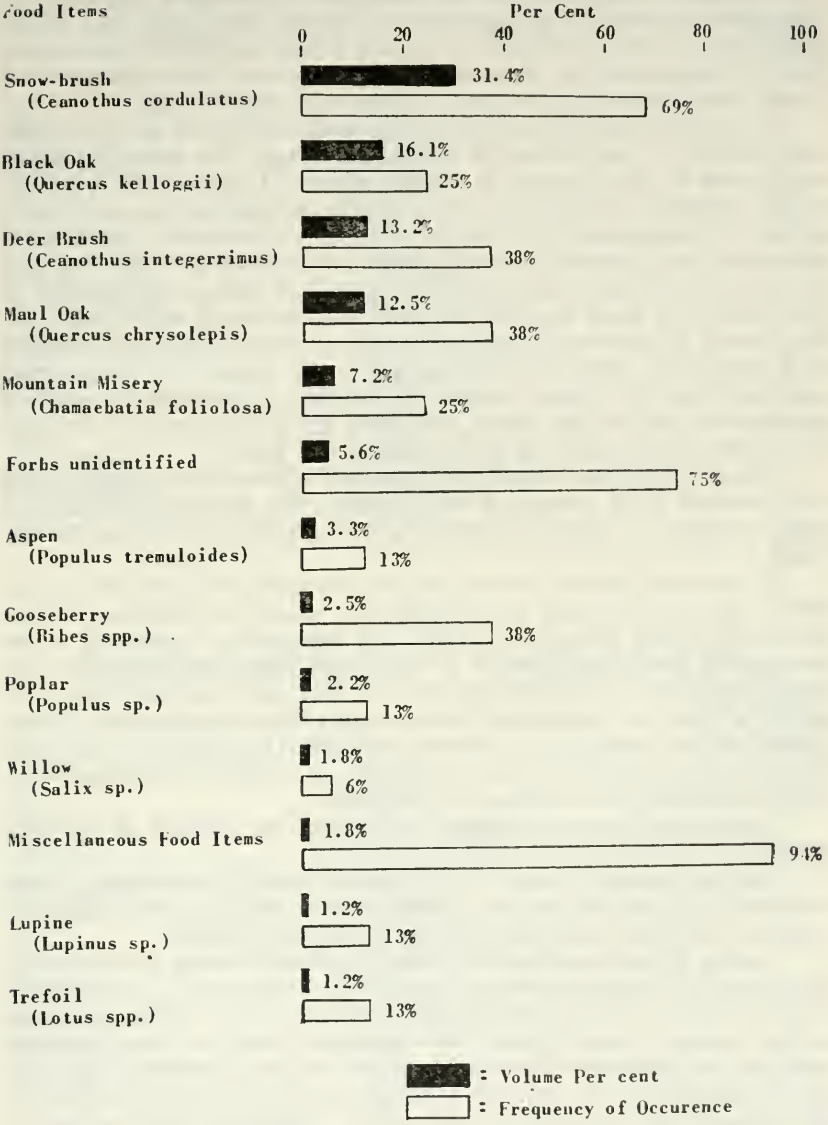


FIGURE 80

RESULTS

Following completion of the analyses of individual stomachs the data were summarized by segregating samples taken from the winter range and the summer range. In Figure 79 are shown the percentages both by volume and by frequency of occurrence of the principal food items (over 1 percent by volume) eaten on the winter range.

It will be noted that browse species made up over 89 percent of the total volume of food taken on the winter range. The most important single item in the diet was mountain misery (*Chamaebatia foliolosa*) which composed 37.3 percent of the food by volume and occurred in 75 percent of the stomachs. The oaks (*Quercus* spp.) were next in importance making up 14.3 percent by volume of the total winter diet and occurring in 63 percent of the stomachs. Acorns as well as leafage are included in this total. Both fresh and dry leaves of oaks occurred in the stomachs. Buck-brush (*Ceanothus cuneatus*) ranked third in importance forming 12.2 percent by volume and occurred in 63 percent of the samples analyzed from the winter range. Manzanita (*Arctostaphylos* spp.) is abundant on the winter range and made up 11.2 percent of the total food eaten, being taken by 65 percent of the deer.

Grass (Gramineae) made up 9.1 percent of the winter diet in volume and occurred in 92 percent of the stomachs. The heaviest utilization of grass occurred on succulent young growth following fall and winter rains.

It seems of interest to note that almost half (48.5 percent) of the diet of the Jawbone deer herd during the winter was made up of two species of plants (mountain misery and manzanita) neither of which has usually been considered to be important deer food plants by most range technicians. The basic reasons for this apparent extensive utilization of these two plants by deer are not evident simply from identification of food occurring in stomach samples. It is suggested that field and laboratory studies of range condition, availability and palatability may be necessary to provide an explanation.

Those food items amounting to less than one percent of the total diet on the winter range are shown in Table 1.

The food taken by deer of the Jawbone herd on the summer range is shown in Figure 80 both by volume percent and frequency of occurrence of the items amounting to over 1 percent volume.

During the summer period browse amounted to over 90 percent of the total diet. The two species of *Ceanothus*, snow-brush (*C. cordulatus*) and deer brush (*C. integerrimus*) formed 44.6 percent of the food eaten on the summer range. Second in importance were the oaks (*Quercus kelloggii* and *Quercus chrysolepis*) comprising 28.6 percent of the diet. Mountain misery (*Chamaebatia foliolosa*) was not as heavily utilized on the summer range as on the winter range. It occurred in 25 percent of the stomachs and composed 7.2 percent of the diet by volume.

Grass and manzanita (*Arctostaphylos* spp.) which were important in the winter diet occurred frequently in the summer diet but the aggregate volume of each was less than 1 percent.

The miscellaneous food items (less than 1 percent by volume) are shown in Table 2.

TABLE 1

Miscellaneous Food Items Eaten by 24 Deer on the Winter Range

Scientific name	Common name	Frequency of occurrence in percent
Fungi	Fungus	13
Lichen	Lichen	13
Bryophyta	Moss	8
Dryopteris arguta	Wood-fern	4
Pityrogramma triangularis	Gold-fern	4
Polystichum munitum	Sword-fern	4
Polypodiaceae	Fern family	17
Pinus spp.	Pine	46
Abies concolor	White fir	4
Liliaceae	Lily family	4
Rumex acetosella	Sheep sorrel	4
Montia sp.	Indian lettuce	4
Umbellularia californica	California laurel	4
Cercocarpus betuloides	Mountain mahogany	17
Adenostema fasciculatum	Chamise	4
Rosaceae	Rose family	4
Cercis occidentalis	Western red-bud	8
Lupinus sp.	Lupine	4
Medicago sativa	Alfalfa (trap bait)	4
Medicago sp.	Bur Clover	4
Trifolium sp.	Clovers	4
Lotus sp.	Trefoil	4
Erodium sp.	Filaree	4
Aesculus californica	Buckeye (fruit fragments)	4
Rhamnus californica	Coffee berry	4
Ceanothus integerrimus	Deer-brush	8
Eriodictyon californicum	Yerba santa	8
Compositae	Compositae flowers	4

TABLE 2

Miscellaneous Food Items Eaten by 16 Deer on the Summer Range

Scientific name	Common name	Frequency of occurrence in percent
Fungi	Fungus	56
Lichen	Lichen	44
Bryophyta	Moss	6
Pteridium aquilinum	Western bracken fern	6
Polypodiaceae	Fern family	19
Pinus spp.	Pines	25
Abies spp.	Firs	13
Libroccdrus decurrens	Incense cedar	19
Gramineae	Grass	69
Liliaceae	Lily family	13
Quercus sp.	Oak (unidentified)	6
Polygonum sp.	Knotweed	6
Rumex sp.	Dock	6
Eriogonum sp.	Wild buckwheat	6
Potentilla sp.	Five finger	6
Amelanchier alnifolia	Western service berry	19
Medicago hispida	Bur clover	6
Trifolium sp.	Clover	6
Lotus americanus	Spanish clover	6
Arctostaphylos sp.	Manzanita	19

SUMMARY

Forty stomach samples, 24 from the winter range and 16 from the summer range, were collected from the Jawbone deer herd (Tuolumne County) during the period from 1947 to 1949 inclusive. Samples were obtained during every month of the year.

Analysis of this material revealed over 89 percent of the winter food to be browse plants. Most important winter food plants were mountain misery (*Chamaebatia*), oaks (*Quercus* spp.), buck brush (*Ceanothus cuneatus*), manzanita (*Arctostaphylos*) and grass.

Most important food plants from summer range samples were snowbrush (*Ceanothus cordulatus*), deer brush (*C. integerrimus*), oaks (*Quercus kelloggii* and *Q. chrysolepis*), and mountain misery (*Chamaebatia foliolosa*).

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AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND CANADA IN 1949-50 *

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Anita E. Daugherty and Leo Pinkas
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This is a fourth report on age and length composition of the catch of sardine (*Sardinops caerulea*) off the Pacific Coast of the United States and Canada and covers the 1949-50 season. There was no fishery for sardines off the Canadian, Washington or Oregon coasts in this season, and the tables include California records only. Tables for the 1948-49 season included the interseason fishery in California. There was no interseason fishery of any consequence in 1949-50.

In past seasons some fish have been trucked from one port to another, and records for these trucked fish were given under the region where processed. In the tables presented for 1949-50, these trucked fish have been included in the region where landed, and thus the San Francisco and Monterey figures show no records of Southern California fish. Such southern landings which were trucked north are included in the San Pedro totals. San Pedro totals also include landings made at Port Hueneme.

Methods of sampling the catch and determining ages were described by Felin and Phillips (1948). The method of sampling gave a random distribution of scale samples in accordance with the size distribution of the sardines in the catch. During the season just past, as in former seasons, each sample consisted of 50 fish taken at random from the catch.

As in former years, the total number of fish caught was calculated from the number of tons landed at each port each week divided by the average weight of the sardines during that time interval. These calculated numbers of fish caught during each lunar month at each port were apportioned to individual year classes according to the percentage representation of each year class in the scale samples. These numbers are shown in Table 9.

The average length and standard error of the mean for each year class by ports are given in Table 7. Calendar dates for the lunar months of the 1949-50 season are shown in Table 8.

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* Submitted for publication March, 1950.
† Published by permission of the Director, U. S. Fish and Wildlife Service.

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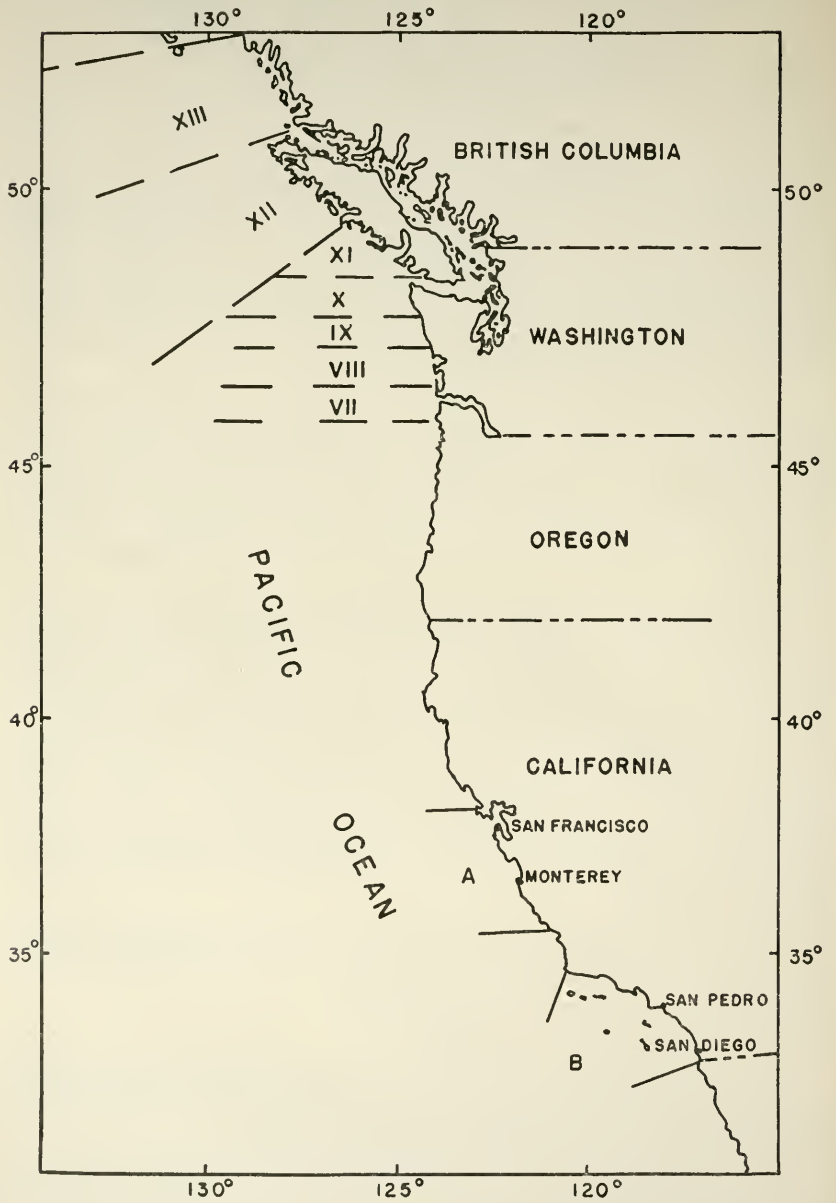

FIGURE 81. Sardine fishing areas. VII-XIII, areas in the Pacific Northwest fishery. A, San Francisco-Monterey fishing grounds. B, Southern California fishing grounds.

TABLE 1

Length Composition of the 1948 Year Class, Age 1, in 1949-50

Length mm.	San Francisco			Monterey			San Pedro			California		
	M	F	T	M	F	T	M	F	T	M	F	T
166				1		1				1		1
168												
170				1		1				1		1
172				1	1	2	2		2	3	1	4
174							1		1	1		1
176				1		1	1	3	4	2	3	5
178					1	1	2	1	3	2	2	4
180					1	1		2	2		3	3
182							1	3	4	1	3	4
184	1		1				4	2	6	5	2	7
186							7	3	10	7	3	10
188							1	4	5	1	4	5
190				1	2	3	4	2	6	5	4	9
192				1		1	3	6	9	4	6	10
194				1	1	2	3	5	8	4	6	10
196	1		1	1		1	2	5	7	4	5	9
198							1	4	5	1	4	5
200		1	1		1	1					2	2
202							1		1	1		1
204								1	1		1	1
206		1	1					1	1		2	2
Totals	2	2	4	8	7	15	33	42	75	43	51	94

TABLE 2

Length Composition of the 1947 Year Class, Age 2, in 1949-50

Length mm.	San Francisco			Monterey			San Pedro			California		
	M	F	T	M	F	T	M	F	T	M	F	T
174					1	1					1	1
176								1	1		1	1
178												
180				1		1				1		1
182					1	1	2		2	2	1	3
184	2	1	3	1	2	3	2	1	3	5	4	9
186		1	1	2	5	7	5	7	12	7	13	20
188	3	1	4	6	2	8	7	6	13	16	9	25
190				8	5	13	12	6	18	20	11	31
192				4	8	12	12	14	26	16	22	38
194		2	2	15	12	27	10	13	23	25	27	52
196	2	5	7	18	11	29	18	14	32	38	30	68
198	7	8	15	34	13	47	10	18	28	51	39	90
200	11	5	16	25	18	43	7	10	17	43	33	76
202	7	8	15	22	22	44	9	10	19	38	40	78
204	10	4	14	22	21	43	7	8	15	39	33	72
206	6	6	12	18	16	34	2	5	7	26	27	53
208	5	7	12	19	21	40	7	3	10	31	31	62
210	8	6	14	21	14	35	2	2	4	31	22	53
212	5	5	10	10	17	27	1	3	4	16	25	41
214	6	3	9	10	11	21	1	3	4	17	17	34
216	4	7	11	10	16	26	2	3	5	16	26	42
218	1	7	8	6	5	11	2	1	3	9	13	22
220	3	3	6	3	7	10	1	4	5	7	14	21
222	1	2	3	2	3	5	1		1	4	5	9
224	1	3	4	3	5	8				4	8	12
226	1	3	4	3	3	6		1	1	4	7	11
228	1	1	2	1	1	2				2	2	4
230	2	2	4							2	2	4
244		1	1								1	1
246	1		1							1		1
Totals	87	91	178	264	210	504	120	133	253	471	464	935

TABLE 3

Length Composition of the 1946 Year Class, Age 3, in 1949-50

Length mm.	San Francisco			Monterey			San Pedro			California		
	M	F	T	M	F	T	M	F	T	M	F	T
186							1		1	1		1
188							1		1	1		1
190							4		4	4		4
192				1		1	1	3	4	2	3	5
194				1		1	12	1	13	13	1	14
196	1		1				6	4	10	7	4	11
198				6	1	7	6	2	8	12	3	15
200	1		1	2		2	14	3	17	17	3	20
202				6	2	8	10	12	22	16	14	30
204	1		1	3	1	4	12	10	22	16	11	27
206				5	2	7	12	6	18	17	8	25
208	3		3	5	3	8	13	12	25	21	15	36
210	1	2	3	5	4	9	7	7	14	13	13	26
212	4		4	7	8	15	4	9	13	15	17	32
214	2		2	4	9	13		3	3	6	12	18
216	5	2	7	8	7	15	2	6	8	15	15	30
218	3	8	11	11	6	17	5	4	9	19	18	37
220	6	4	10	10	8	18	1	5	6	17	17	34
222	6	2	8	2	9	11	1	4	5	9	15	24
224	4	3	7	2	6	8	2	2	4	8	11	19
226		2	2	5	5	10		1	1	5	8	13
228	2	3	5	1	2	3		1	1	3	6	9
230		4	4		3	3					7	7
232	1	4	5	1	2	3				2	6	8
234		1	1		2	2					3	3
236					1	1					1	1
238	1	1	2							1	1	2
240		1	1	2		2		1	1	2	2	4
242				1		1				1		1
244												
246					2	2					2	2
248												
250												
252					1	1					1	1
Totals	41	37	78	88	84	172	114	96	210	243	217	460

TABLE 4

Length Composition of the 1945 Year Class, Age 4, in 1949-50

Length mm.	San Francisco			Monterey			San Pedro			California		
	M	F	T	M	F	T	M	F	T	M	F	T
192							2		2	2		2
194							2		2	2		2
196							1		1	1		1
198							2	3	5	2	3	5
200				2		2	1	2	3	3	2	5
202				1	1	2	3	1	4	4	2	6
201							3	1	4	3	1	4
206		1	1	1	1	2	5	3	8	6	5	11
208				2	2	4	2	4	6	4	6	10
210				3	3	6	4	1	5	7	4	11
212		1	1	5	2	7	1	2	3	6	5	11
214				2	2	4	4	3	7	6	5	11
216	1	1	2	4	2	6				5	3	8
218	3	2	5	5	3	8		3	3	8	8	16
220	1	3	4		2	2		2	2	1	7	8
222	2	1	3	5	4	9		1	1	7	6	13
224	2	2	4	3	2	5	1	1	2	6	5	11
226				1		1	1		1	2		2
228		1	1	1	1	2				1	2	3
230	1		1					1	1	1	1	2
232	1	1	2		1	1				1	2	3
234					1	1					1	1
236		1	1					1	1		2	2
238												
240	1		1							1		1
242												
244												
246		1	1								1	1
248												
250												
252												
254					1	1					1	1
Totals	12	15	27	35	28	63	32	29	61	79	72	151

TABLE 5

Length Composition of the 1944 and 1943 Year Classes in 1949-50

Length mm.	1944 Year-class, age 5												1943 Year-class, age 6								
	San Francisco			Monterey			San Pedro			California			Monterey			San Pedro			California		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
198				1		1				1		1									
200								1	1		1	1									
202							1	1	2	1	1	2									
204							2		2	2		2									
206				1		1	1	3	4	2	3	5									
208				2		2	3		3	5		5									
210					1	1	2	2	4	2	3	5									
212				1		1				1		1									
214				1		1	1	1	2	2	1	3									
216					1	1	2		2	2	1	3									
218				1		1	1	1	2	2	1	3									
220	1	1	2	3	1	4		1	1	4	3	7		1	1					1	1
222				5	1	6	1	2	3	6	3	9				1		1	1		1
224		1	1	1	1	2				1	2	3	1		1				1		1
226	1		1				1		1	2		2	1		1				1		1
228		1	1		1	1					2	2	1		1				1		1
230	1		1	1		1				2		2									
232	1	2	3					1	1	1	3	4									
234	1	1	2							1	1	2	1		1				1		1
236					2	2					2	2									
238	1		1							1		1									
240													1		1				1		1
242																					
244		1	1								1	1									
246																					
248																					
250		1	1								1	1									
252														1	1					1	1
254				1		1				1		1									
264					1	1					1	1									
Totals	6	8	14	18	9	27	15	13	28	39	30	69	5	2	7	1		1	6	2	8

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TABLE 6

Length Composition of the 1942, 1941, 1940 and 1938 Year Classes in 1949-50

Length mm.	1942 Year-class, age 7									1941 Year-class, age 8			1940 Year-class, age 9			1938 Year-class, age 11		
	Monterey			San Pedro			California			California*			California†			California‡		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
206				1		1	1		1									
208																		
210																		
212																		
214	1		1				1		1									
252											1	1						
262														1	1			
274																	1	1
Totals	1		1	1		1	2		2		1	1		1	1		1	1

* Year class represented in California only at Monterey.
† Year class represented in California only at San Francisco.
‡ Year class represented in California only at San Francisco.

TABLE 7

Number of Fish, Mean Length, and Standard Error of the Mean for Each Year Class in the 1949-50 Season by Region of Catch

Year class	California								
	San Francisco			Monterey			San Pedro		
	No.	M.	S.E.	No.	M.	S.E.	No.	M.	S.E.
1948									
Male	2	190	----	8	182	4.94	33	187	1.34
Female	2	203	----	7	186	4.30	42	190	1.17
Totals	4	196	4.76	15	184	3.04	75	189	0.88
1947									
Male	87	207	1.11	264	204	0.17	120	197	0.76
Female	91	209	1.14	240	205	0.20	133	199	0.76
Totals	178	208	0.79	504	204	0.13	253	198	0.54
1946									
Male	41	218	1.33	88	214	1.08	114	203	0.73
Female	37	224	1.36	84	219	1.07	96	209	0.90
Totals	78	221	0.98	172	216	0.25	210	206	0.60
1945									
Male	12	224	2.90	35	215	1.29	32	206	1.46
Female	15	223	2.98	28	218	2.07	29	211	1.83
Totals	27	223	1.86	63	217	1.14	61	208	1.20
1944									
Male	6	230	6.06	18	219	2.98	15	211	1.97
Female	8	233	5.64	9	228	6.26	13	213	2.80
Totals	14	232	3.24	27	222	2.78	28	212	1.58
1943									
Male				5	230	7.40	1	222	----
Female				2	235	----	----	----	----
Totals				7	232	6.28	1	222	----
1942									
Male				1	214	----	1	206	----
Female				----	----	----	----	----	----
Totals				1	214	----	1	206	----
1941									
Male				----	----	----			
Female				1	252	----			
Totals				1	252	----			
1940									
Male	----	----	----						
Female	1	262	----						
Totals	1	262	----						
1938									
Male	----	----	----						
Female	1	274	----						
Totals	1	274	----						

TABLE 8

Calendar Dates of Lunar Months for the 1949-50 Season

"August"	August 9-September 7
"September"	September 8-October 6
"October"	October 7-November 5
"November"	November 6-December 4
"December"	December 5-January 2
"January"	January 3-February 1

TABLE 9

Age (Year Class) Composition of the Sardine Catch in the 1949-50 Season

(Numbers of fish are given in thousands, i.e., 000 omitted)

	Catch		Number of fish by age (year class)										
			0	1	2	3	4	5	6	7	8	9	11
	Tons	Number	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1938
San Francisco													
"August"	1,875	13,929			8,706	2,980	1,992	251					
"September"	5,166	33,157		663	17,075	10,710	2,023	2,686					
"October"	4,104	29,017		290	17,468	6,529	3,250	1,190					290
"November"	4,687	29,259			18,550	7,812	966	966				965	
"December"	1,208	9,530		476	6,195	2,383	476						
"January"	495	3,904		195	2,538	976	195						
Totals, San Francisco	17,535	118,796		1,624	70,532	31,390	8,902	5,093				965	290
Monterey													
"August"	14,028	116,951		2,456	109,583	4,912							
"September"	50,546	361,531		11,207	250,179	75,560	9,400	11,569	1,808		1,808		
"October"	32,820	226,215			153,148	40,040	20,586	5,655	6,786				
"November"	19,396	142,783		999	56,971	50,117	23,131	11,565					
"December"	10,285	79,064		1,977	51,787	16,999	6,325	1,581		395			
"January"	1,337	10,760		269	7,048	2,313	861	215		54			
Totals, Monterey	128,412	937,304		16,908	628,716	189,941	60,303	30,585	8,594	449	1,808		
San Pedro													
"October"	94,379	839,327		79,736	415,466	239,208	62,950	37,770	4,197				
"November"	6,865	63,459		6,346	24,875	22,464	6,346	2,857		571			
"December"	45,372	412,934		41,293	140,811	148,243	63,179	19,408					
"January"	38,341	353,460		66,450	123,358	127,953	21,561	14,138					
Totals, San Pedro	184,957	1,669,180		193,825	704,510	537,868	154,036	74,173	4,197	571			
San Diego*	3,211	28,852		3,139	12,392	9,343	2,541	1,285	66	86			
Grand totals	334,115	2,754,132		215,496	1,416,150	768,542	225,782	111,136	12,857	1,106	1,808	965	290

* All values for San Diego, except tons landed, were prorated from San Pedro totals.

BASIC DEER MANAGEMENT

(A Story With Pictures)*

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Figure 82

* Submitted for publication March 1950.

Mus. Vert. Zool. No. 3427

FIGURE 83

Deer that spend the summer months on the higher mountain ranges in California are forced out of the mountains by snow in the fall. These deer move down to lower elevations to spend the winter months.

Since the coming of the white man to California, much of the land that once made up the best winter deer ranges has been put to agricultural uses. The more fertile soils have been placed under cultivation. Less fertile lands are often used for pasturing livestock.

Photo by U. S. Forest Service

FIGURE 84

In many cases, migratory deer herds are pushed by snow on the one hand and agriculture on the other into rather limited wintering areas. Often for every 5 to 15 acres of summer range there exists only one acre of winter range. Even where area is less limited, the food supply may be limited where livestock have taken a large share of the forage before the deer arrive.

This is the reason why winter deer ranges generally control the number of migratory deer in this State. No matter how large the summer range, no matter how abundant the summer forage, migratory deer are usually limited to the numbers which their winter ranges can support during the winter months.

Mus. Vert. Zool. No. 5642

FIGURE 85

If there is enough forage on the winter ranges to supply the animals' needs, deer will ordinarily remain healthy. They will keep sufficient fat to protect them from rigorous winter weather. They will produce healthy, vigorous fawns in the spring. But when a migratory deer herd increases to a number whose demand for food exceeds the supply of forage on their most limited range, then . . . trouble starts.

FIGURE 86

Anyone who works with vegetation, be it only a lawn and a few ornamental shrubs, knows that too frequent and too close mowing and pruning will weaken and finally kill out the plants. This applies even more critically to range vegetation. It is not possible to turn on the water sprinkler or open the irrigation gates out on the range.

FIGURE 87

Range plants can withstand a moderate amount of cropping without damage. In fact, a moderate amount of cropping will sometimes stimulate the plants to produce more growth, as has this thrifty bitterbrush stand. Bitterbrush is one of our most important winter deer foods east of the Sierras.

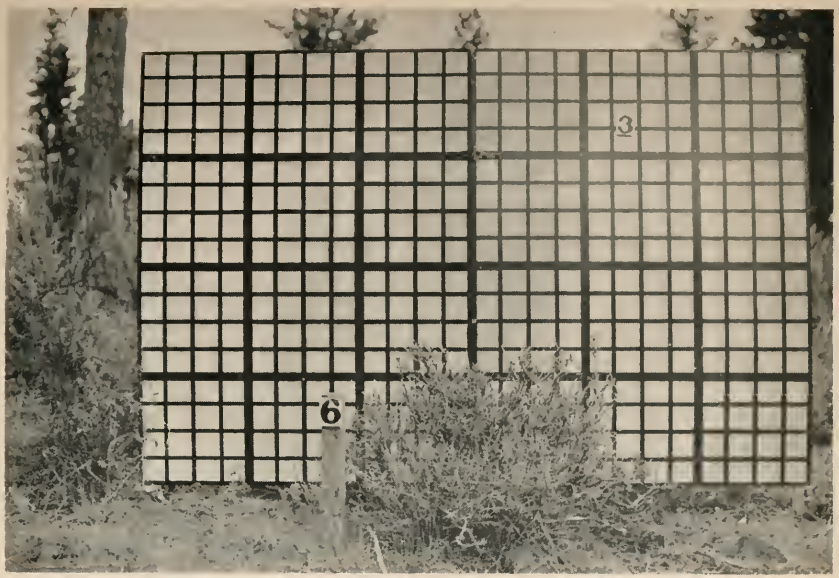

Photo by U. S. Forest Service

FIGURE 88

It has been determined that up to 60 percent of the annual twig growth on a bitterbrush shrub can be cropped each year without harm to the plant.* This may be called the annual crop which may be harvested each year by deer and livestock. The other 40 percent must be left as a maintenance reserve, necessary to sustain the life processes of the plant itself.

* Hormay, A. L. 1943. Bitterbrush in California. Calif. Forest and Range Exper. Sta., Research Note No. 34.

Photo by U. S. Forest Service

FIGURE 89

But when over-abundant deer, livestock or other range animals eat 75 . . . 85 . . . 95 percent of the annual twig growth from bitterbrush shrubs, this plant loses vigor, fails to reseed, declines and finally dies.

FIGURE 90

Sagebrush and rabbitbrush are less choice forage plants east of the Sierras. Deer eat foliage from these shrubs, but usually such plants are so abundant, in relation to choice forage, that individual shrubs receive only light use.

But look at this overcropped rabbitbrush! . . . eaten down to coarse stems on an area where too many deer are present. Hungry animals must eat! Badly hedged sagebrush and rabbitbrush shrubs are an indicator of improper balance between deer numbers and their winter food supply.

FIGURE 91

Overcropping by range animals will kill smaller shrubs and herbs. Tall shrubs and trees present a different problem.

Once such browse plants as mountain mahogany, wild lilac, silk-tassel and juniper grow taller than the reach of deer, they become able to survive even though all the foliage from their lower branches is cropped. But when use of the lower branches for food by deer and other range animals is too heavy, the branches die. The plant may compensate for these dead and damaged twigs by growing more branches and more foliage up high where browsing animals cannot reach it.

Look at the browse line on this mountain mahogany! A deer has no chance for a meal here!

Photo by U. S. Forest Service

FIGURE 92

And there is little chance for a meal here! . . . where juniper has been high-lined as high as deer can reach! This forage is gone forever. And if seedlings and young trees are overcropped and killed, as they are apt to be on overpopulated deer ranges, there is no replacement of this forage for hungry deer.

Photo by U. S. Forest Service

FIGURE 93

What applies to bitterbrush, sagebrush and juniper, applies to all range plants. Here we see the final result of overcropping by deer and livestock on a winter range: The shrubs are dead or dying, the trees are high-lined.

Photo by U. S. Forest Service

FIGURE 94

When a migratory deer herd increases in numbers beyond the carrying capacity of its winter range, the animals are forced to overcrop the desirable forage plants and to turn for forage to less palatable, less nourishing species of vegetation. They are forced to bite deep into the range maintenance reserve, to eat the coarser twigs and stems. As a result, the damaged plants produce less forage each succeeding year, making the problem more and more critical.

FIGURE 95

When deer are forced to subsist on poorer quality forage, they become undernourished. Undernourished deer use up their fat, suffer from cold weather, become weak and subject to disease and parasites. Weak does produce weak fawns, many of which succumb in the early part of their lives.

FIGURE 96

Nature's way of balancing deer numbers with deer food supply is harsh. Once the balance is tipped, once deer become too plentiful for the food supply, not only is there depletion of the range itself, but the deer will die. The deer may die from starvation, disease, or parasitism, all directly or indirectly a result of malnutrition.

The most publicized die-off of deer as a result of forage depletion occurred on the Kaibab National Forest in Arizona. Here 60 percent of a deer herd estimated to have numbered at least 27,000 animals is reported to have died during the winters of 1923-25.

The same thing has happened in many states. Nature's way of taking care of deer range problems is not only harsh, but wasteful.

FIGURE 97

So far, we have spoken about migratory deer, that is deer that migrate with the seasons between summer and winter ranges. In the coastal region of California where snow is not common, deer often remain on relatively small areas year-long. Such deer are called nonmigratory or resident deer.

The range problems on nonmigratory deer ranges are somewhat different from those we have discussed. The critical period for deer on these ranges is often the late summer when herbage is dry and the forage offered by many shrub species is low in food value. This lasts until the first rains bring out green food. Cold winters, when heavy frosts kill back all new growth, are also critical.

FIGURE 98

All the plants that grow on a range are not deer food. Most deer found dead from malnutrition have full stomachs. But their stomachs are full of vegetation and other materials of low food value.

Because a range is covered with brush does not necessarily mean that deer food is plentiful. Often, plants that provide good deer food at one season of the year are of little value during other seasons. Many plant species are seldom eaten by deer except as a last resort because they are poisonous, or because they have little food value.

FIGURE 99

On nonmigratory deer ranges, the number of deer is often limited to that which certain plant species can maintain during critical food periods.

The forage from most herbs and many chaparral brush species looses food value as the dry season progresses. When the amount of protein in this forage drops below 5 percent, the deer are in trouble.* The deer are in trouble unless other plant species are present on the range which maintain high food value during critical periods. The holly-leaf cherry shown above is such a shrub. See how it is hedged from heavy use!

As in the case with migratory deer herds, proper management of deer on nonmigratory deer ranges must aim to balance deer numbers with critical food supplies.

* Einarsen, Arthur S. 1946. Crude protein determination of deer food as an applied management technique. Trans Eleventh North American Wildlife Conf., pp. 309-312.

FIGURE 100

Many nonmigratory deer ranges are closely adjacent to cultivated lands. When native food is short on a deer range, a succulent field of alfalfa or clover, a patch of corn or cabbage, an orchard of young almond or peach trees, looks good to hungry deer.

Shortage of critical native foods on deer ranges is often the direct cause of agricultural damage by deer. At first deer come to croplands because they are hungry. And, once they develop a taste for grain, lettuce, oranges, apples, they are apt to come back for more. Look what deer have done to the young almond trees shown in the picture.

The only practical way to solve the increasing deer damage problem in this State is, in most instances, to dispatch the offending deer, and then bring the other deer on adjacent ranges in balance with their food supply by increasing the native forage (where possible) or by reducing the number of deer on the ranges.

FIGURE 101

Many game agencies in the United States have tried to remedy natural food shortages by feeding deer hay or other artificial foods. But transportation of artificial foods into the rough, inaccessible areas where many deer spend their time is often difficult and extremely costly.

Mus. Vert. Zool. No. 5503

FIGURE 102

Also, in areas where artificial foods are supplied to deer, the animals will soon kill out all the native forage plants in the vicinity in efforts to obtain a more natural diet. Then, the deer will fail to do well on the strictly artificial diet upon which they have then become dependent for their existence. In 1942, Colorado spent $38,000 for winter feeding on the Gunnison winter deer range alone. Five thousand deer died that winter on the Gunnison range. In one canyon 253 dead animals were found on 40 acres. Practically all the animals died with stomachs full of alfalfa and concentrates.*

* Hunter, Gilbert N. and Yeager, Lee E. 1949. Big game management in Colorado; Jour. Wildlife Management, vol. 13, p. 392-411.

Photo by U. S. National Park Service

FIGURE 103

Finally, when deer concentrate at artificial feeding stations, disease and parasites can spread more easily amongst them.

Deer experts have found that artificial feeding only makes the problem worse and prolongs action for a proper solution. Most game departments have abandoned this practice.

FIGURE 104

Game agencies have spent thousands of dollars in attempts to plant palatable deer forage on depleted game ranges. Where this planting was done without first reducing the number of deer to a low level, the practice has failed. In Wisconsin, for example, 40 to 60 million tree seedlings are produced each year in nurseries for planting in that State's reforestation program. But surveys indicate that their deer herd is crippling over 660,000,000 seedlings annually throughout the forests of that state.*

* Swift, Ernest. 1948. Deer damage to forest reproduction survey. 38th Convention Int. Assn. of Fish and Game Commissioners.

Photo by U. S. Forest Service

FIGURE 105

Planting browse seeds or transplants is still in the experimental stage in California. Planting may show promise for improving deer ranges where deer and livestock numbers can be held at low stocking levels until the plants are well established.

However, when animal numbers are reduced to low levels, planting often will become unnecessary. If there exists sufficient native seed stock on the range, nature will often reseed and improve the area more efficiently, and much less expensively, than can artificial plantings.

FIGURE 106

Fire offers no short-term benefits to deer on winter ranges east of the Sierras. In fact, fire, by destroying the browse plants and favoring herbaceous vegetation, is detrimental and can lead to wholesale losses of deer on winter ranges in the intermountain area.

In timber types, extensive use of fire is not advisable. While fire may be used in forest types to open up dense tree canopies, let in more sunlight, lessen tree-root competition, and thus allow nourishing forage plants room to grow, usually timber values are much too high to sacrifice for the benefit of deer except in special cases.

Logging of timber opens up the forest and serves the same purpose as fire, without economic loss. It should be remembered also that, as far as migratory deer are concerned, forest types are summer range. Summer ranges are generally not the areas where deer food is short.

FIGURE 107

In the chaparral brush areas west of the Sierras and in certain woodland vegetation types, prescribed and controlled burning may be used to improve deer ranges in some instances. Many chaparral forage species sprout from the stumps after they are burned. These sprouts offer excellent food for deer.

Tall, dense, decadent stands of brush offer little available forage to deer. Where fire is used wisely to open up these brush fields, and the burned areas are reseeded to grasses to stabilize the soil and to hold vegetation patterns, deer ranges can be improved by well-planned and careful burning.

But frequent burning depletes both the soil and the vegetation. Studies in Oregon indicate that the food value of deer forage drops where burning is too frequent. And there is no place at all for unplanned, uncontrolled, wild fires on the range.

Photo by U. S. Forest Service

FIGURE 108

Fire may prove a useful tool in places but it is no panacea. California's deer range problems cannot be solved with a box of matches. Fires can destroy timber, reduce protective cover on watersheds, cause damaging floods, induce accelerated soil erosion as shown in the picture. Deer management must be correlated with other natural resource management in California to be acceptable and successful in the long run.

The California Division of Fish and Game is making intensive studies to determine where, how, and when fire can be used for deer range improvement without endangering the other resources of this State.

Mus. Vert. Zool. No. 5510

FIGURE 109

The game departments in most states where deer are abundant are turning to deer management as a solution for principal deer problems.

Deer management consists of production on each management unit of the maximum number of harvestable animals that may be raised year after year without depleting the forage resource and without serious conflict with other important land uses.

The deer manager works to keep the herd of breeding deer in balance with its food supply. He does this by allowing and encouraging sportsmen to bag the surplus animals, both male and female, for recreation and food, rather than leave them for nature to harvest through malnutrition and disease.

Photo by U. S. Forest Service

FIGURE 110

The Division of Fish and Game has initiated deer management programs on deer ranges in Modoc, Lassen, Plumas, Tehama and Tuolumne counties.

Here we see the Devil's Garden interstate winter deer range in Modoc County. Deer from Oregon and California come to this critical area to spend the winter months. Livestock are permitted to graze on these national forest lands during the summer season.

Now the U. S. Forest Service, the Oregon Game Commission and the California Division of Fish and Game have agreed to divide the annual crops of shrub forage on this area between livestock and deer on a 50/50 basis. They have agreed to set ceilings on the numbers of animals that will be allowed on the range. When either deer or livestock take more than their quota of forage, the surplus animals will be removed. Thus, the palatable range vegetation will be left with sufficient growth to sustain the plants, and the range will produce forage to feed livestock and deer year after year on a sustained yield basis.

FIGURE 111

Where large migratory deer herds concentrate during the winter on privately-owned livestock ranges, an unjust burden may be thrown on the landowners. Such areas usually become badly depleted as a result of the combined use of livestock and deer. As a result, both the deer and the livestock suffer.

In a few places where important deer herds are involved, the Division of Fish and Game is purchasing land. The picture shows part of the Tehama winter deer range, where lands are being purchased with Federal Wildlife Restoration and Fish and Game Preservation Fund moneys. Such lands are then managed primarily for deer. Livestock grazing is permitted only where a surplus of forage exists.

FIGURE 112

Here is a view of the Lassen-Washoe interstate winter deer range, an area on which a critical deer food problem has existed for several years. Deer, which summer mostly in the Plumas National Forest, in California, come to winter on intermixed private and public lands on both sides of the Nevada-California state line. Here, also, the Division of Fish and Game is puchasing land in order to insure an adequate supply of winter forage for an important deer herd.

While the purchase of lands for deer range may be justified in certain instances, obviously it is neither possible nor desirable for the Division of Fish and Game to buy all areas where deer problems exist. Deer must fit into existing economic patterns to hold their place in the modern world. Ordinarily, private land problems are best solved by holding deer numbers at levels in balance with other land uses. Even where deer ranges are purchased, ceilings on breeding herds should be established in order to insure sustained yield.

FIGURE 113

On the Fishlake National Forest, in Utah, a herd of approximately 44,500 rocky mountain mule deer showed an average net production for harvest of 24 percent year after year, after all classes of losses, including crippling loss, were deducted. This occurred in a deer herd which was open to shooting of both buck and doe deer.*

Studies made in several areas in California indicate that our deer herds generally have a productivity equal to, or better than, that of the Fishlake herd. Sportsmen harvest part of the number of buck deer produced each year. It is estimated that hunters take a maximum of 7 to 10 percent of the State's deer each season. What happens to the rest of the annual crop, both male and female?

* Robinette, W. L., and Olsen, O. A. 1944. Studies of productivity of mule deer in central Utah. Trans. Ninth North American Wildlife Conf., p. 156-161.

FIGURE 114

Every deer range has its carrying capacity. The carrying capacity of a deer range may be compared to a five-gallon bucket. As deer increase they gradually fill the bucket. Once the range bucket is full, it will hold no more. Unless a gallon or more is removed each hunting season, the seasonal increase will become a surplus which will run over and be wasted. Not only will the surplus be wasted, but as it runs over the sides of the range bucket it will wear down the rim. By overcropping, weakening, and killing the forage plants, each succeeding crop of surplus deer lowers the capacity of the range bucket; each year the range bucket will hold less and less, and waste more and more.

FIGURE 115

Surveys tell us that many of the deer range buckets in California are now full and overflowing. The annual surplus of deer is here, to use or to let waste.

Under deer management, every effort is made to harvest the full surplus of bucks and does each season. By holding breeding herds to the numbers their ranges can properly carry, both the deer herds and the deer ranges are maintained to produce on a sustained yield basis.

Sustained yield in deer management means improving and maintaining deer ranges, both soil and vegetation, so that these ranges will continue to produce volumes of good forage year after year.

Sustained yield means harvesting the full crop of surplus deer, both male and female, produced each year by the breeding herd.

Sustained yield means conservation through wise use.

Properly stocked deer ranges will produce abundant deer forage. Plentiful forage will maintain healthy, productive breeding deer herds. Healthy, productive deer will produce more harvestable animals.

Thus can California's sportsmen expect more deer for the bag through deer management.

THE PISMO CLAM *

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INTRODUCTION

The Pismo clam is one of the most thoroughly investigated bivalves on the Pacific Coast. More is known of its life and habits than any of the many different species of pelecypods found in California waters with the possible exceptions of the oyster and the mussel. However, most of the knowledge concerning the Pismo clam can be found only after diligent perusal of many published works. The present paper has been written

* Submitted for publication February 1950.

to compile in a popular account as much as possible of the known information on this clam. Some of this information has been published previously while much of it is here printed for the first time. For those who wish more detailed or scientific accounts a complete list of references has been included.

GENERAL INFORMATION

Fossil remains of Pismo clams, *Tivela stultorum* Mawe, have been found in Pleistocene deposits at least 25,000 years old at Santa Barbara and San Diego. This indicates that these clams have been present on our coast since about the time of the ice age. It was not until 1823, however, that the Pismo clam was described and named by the scientist Mawe. This name was taken from the Latin and is generally credited as being "one of Mawe's little jokes." Literally the word "stultorum" means "foolish" or "simple." In 1807 Heinrich Link, a German scientist, described and named the genus *Tivela* in honor of Tivel Adams. An unverified story states that Tivel Adams was Link's assistant. If this is true Mawe's little joke in naming the species *stultorum* becomes quite pointed.

Pismo clams are found on nearly all of the exposed sandy beaches between Halfmoon Bay near San Francisco (latitude 37° 30′ N., longitude 122° 30′ W.) and Socorro Island off the coast of Mexico (latitude 18° 46′ N., longitude 111° 00′ W.). They have been taken from sand exposed by an average low tide into water exceeding 80 feet in depth. The heaviest concentration of clams is usually found around the mean low mark (the waters edge at 0.0 tide).

At Pismo Beach (about half-way between Los Angeles and San Francisco), as the name suggests, the greatest abundance of clams on the coast of California can be found. The name Pismo was taken from the Indian word "pismu" meaning "tar." (Large deposits of asphalt or bitumen are found in this area.) First printed usage of the word was in the year 1840 when the Pismo Land Grant was issued by the Mexican government. The town of Pismo was founded in 1891 when the Southern Pacific Railroad completed the last link of the coast route from San Luis Obispo to Elwood. In 1904 "Pismo" became "Pismo Beach" which it remains today.

The clam probably inherited its name soon after the first white settlers moved into the area through misinterpretation of the Indian word "pismu." It is not difficult to realize a shortening of the wording "the place which the Indians call pismu where large clams can be found" to "clams at pismu" to the present "Pismo clams."

ANATOMY

The Pismo clam has two symmetrical shells which are hinged together at one end. When living in its natural habitat the hinged side is always pointed toward the surf, the open side toward the beach, and the dark raised ligament at the center of the hinge is up. On many beaches, a colony of hydroids, *Clytia bakeri*, is frequently found growing on the shell on the end nearest the surface. This hydroid colony resembles a tuft of hair or fine seaweed.

The shells of individual clams vary considerably in both color and pattern. The characteristic color is a pale buckskin, though they range from this to a dark chocolate. Occasional individuals are marked with chocolate brown lines radiating out to the margin. A third color pattern consists of three light streaks radiating from the hinged end; these are not so conspicuous as the "striped" individuals and generally the light streaks disappear completely as the clam ages. The percentage of striped clams averaged 4.6 for over 3,000 clams of all ages examined on four widely separated beaches. (Pismo, Hueneme, Sunset, La Jolla.) La Jolla had the smallest percentage of striped individuals, 4.38, and Hueneme had the greatest, 4.85. This tendency for stripes is a natural variation and the sex of the clam cannot be determined by the color pattern.

FIGURE 116. Pismo clam patterns: Left, typical clam; center, three striped or trident; right, striped. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

The outside of the shell is covered with what appears to be a thin coat of varnish, the periostracum, which cracks and peels off when the shell is exposed to direct sunlight. The inside of the shell has a thin fleshy membrane attached to its whole surface. This membrane is the mantle and its function is to secrete (manufacture) the shell. The smooth inside part of the shell is secreted by the whole mantle while the middle and outer layers of the shell including the stripes or rays and the periostracum are secreted by the thick outer edge of the mantle. The umbo or beak is the oldest part of the clam and is located at the hinged end. A ligament unites the two halves of the shell and interlocking teeth below the umbo make up the hinge. It is by these teeth and the impressions of the muscle and mantle attachments that clam shells are identified. The two adductor muscles close the two valves of the clam; when these muscles are relaxed the hinge ligament causes the shells to gape open.

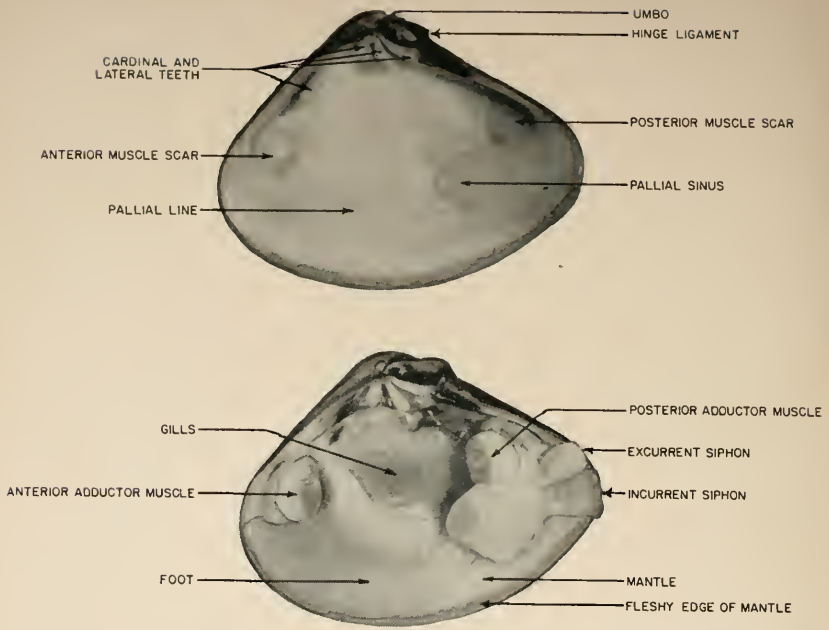

FIGURE 117. Pismo clam which has been opened to illustrate general anatomy. In the lower picture the mantle on one side has been removed leaving the rest of the meat in place. In the upper picture this meat has been removed to show the markings on the inside of the shell. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

In life when the clam opens, the edges of the mantle are extended to the margin of the shell, the siphons appear at the end where the ligament is located and sometimes the axe-shaped foot is thrust out between the two halves of the shell and is used as a very effective digging tool. The gills are found in the mantle cavity on either side of the base of the foot and are usually slightly darker in color than the foot. The reproductive organs, which may be seen by slicing lengthwise through the foot, are the soft whitish or yellowish part through which the intestine loops. The large dark mass (about the size of a small marble) which lies at the base of all these organs is the liver. Frequently, when cleaning a clam an amber colored, rod-shaped organ an inch or more in length and about the thickness of a match-stick pops out of the visceral mass. This is the crystalline style which the clam uses as an aid to digestion, and is not a worm or parasite as many people believe.

NUTRITION

General

During high tide and other periods when the living Pismo clam is covered by water it may be found just beneath the surface of the sand with the siphon extended to the surface. Water taken in through the incurrent siphon passes over the gills where food particles are removed and then passes out the excurrent siphon. The incurrent siphon has a fine net of branched papillae or fine fingerlike projections across the

opening which forms a screen to exclude large grains of sand and yet permit the passage of water and the microscopic food that it contains.

The Pismo clam is a typical scavenger or detritus feeder although living one-celled organisms form a considerable portion of the diet. When feeding begins, mucus is secreted either at the upper edges of the gills and carried in a sheet by the frontal cilia (hairlike processes capable of a lashing movement) to the free edges of the gills or it is secreted more or less uniformly over the entire surface. It is carried in strings along the edges of the gills to the labial palps (fleshlike appendages in each side of the mouth). The palps remove all undesirable particles and allow the rest of the material to pass intact with the strings of mucus directly into the stomach. This mucus which covers the entire gills intercepts all particles from the current of water which passes through these gills and out the dorsal or excurrent siphon.

Food

More than half of the contents of the stomach and intestine is sand. Particles of sand 0.2 to 0.3 mm. in longest diameter (1 mm. = approximately $\frac{1}{25}$ inch), thin fragments of periostracum and chitin nearly one millimeter in length and filamentous algae 1.5 mm. long are the largest objects observed in the stomach by Dr. Wesley R. Coe. In contrast with these relatively large objects the mucus sheet secreted on the gills is so efficient that it can filter particles of extreme minuteness including the smallest bacteria.

In addition to the siphonal papillae and the labial palps the ingested particles encounter a third sorting mechanism upon reaching the stomach. This consists of a food sorting caecum or blind pocket in which the particles are kept rotating by ciliary action, the smaller particles being carried toward the opening into the digestive diverticula or liver, while the larger particles are diverted toward the intestine. The kinds of food utilized by Pismo clams includes dinoflagellates, diatoms, bacteria and other algae, minute zooplankton, gametes of invertebrates, zoospores of algae and detritus from the disintegration of plant and animal cells.

It has been estimated that a three-inch clam filters an average of 60 liters (3.785 liters per gallon) of water during its feeding times each day or 2,000 liters a month. This amounts to approximately 5,800 gallons of water per year which is strained by the one three-inch clam. At La Jolla this amount of water would contain about 110 grams (3.88 ounces, at 28.35 grams per ounce) of potential food; of this the animal stores one to two grams in the body (weight increase) and discharges as gametes (eggs or sperm) one to three grams annually. Of the remainder, some is used as energy while the greatest amount is probably passed off as waste.

GROWTH

General

The Pismo clam grows continuously throughout its life. As the clam grows, the shell not only becomes thicker but increases in diameter. This rate of growth can be accurately measured and studies indicate that it varies considerably from month to month, the greatest increase taking place in the spring, summer, and early fall months with a definite slowing down during the late fall and winter months. The growth rate varies

on different beaches and in fact even on the same beach at localities just a mile or two distant from each other.

On most beaches, however, the average yearly increase in diameter during the first four years of life is slightly more than three-fourths of an inch (20 mm.). After four years the growth rate usually slows down until eventually at around age 10 the increase is usually not more than one-eighth of an inch per year. On some beaches the growth rate has been found to be more than one and one-half inches a year the first three or four years. On most beaches some clams attain a legal size of five inches in five years but many clams do not reach this size until eight or nine years. On some beaches it has been found that many clams attain a legal five inches in three years and nearly all before age six. It takes about 45 legal sized clams to make 10 pounds of meats (drained weight).

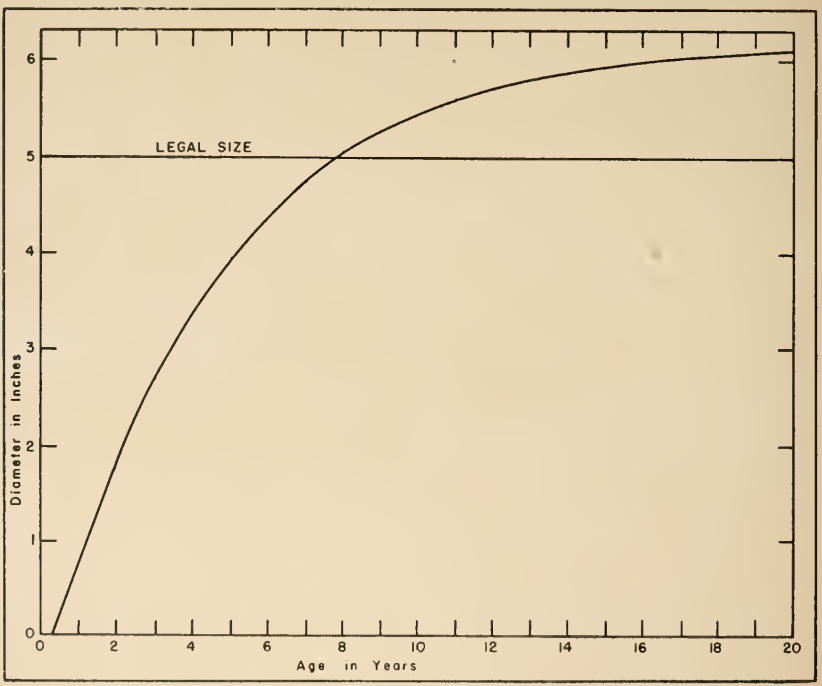

FIGURE 118. Average rate of growth of Pismo clams at Pismo Beach. These averages have been determined from the results of the annual census for the years 1923 through 1949 (excluding 1942 through 1945).

The largest clam of which there is a record was $7\frac{3}{8}$ inches (187 mm.) across and was about 26 years old. Another huge clam from Pismo Beach was $7\frac{1}{4}$ inches (183 mm.) in diameter, 3 pounds and 13 ounces in weight and 23 years old; and a third was $6\frac{3}{4}$ inches in diameter and 27 years old (weight not available on this individual). A number of clams from Lower California have been aged as over 35 years though not many are more than $6\frac{1}{2}$ inches in diameter at this age. The smallest clam that I have collected was taken at La Jolla, California, and measured slightly less than $\frac{3}{32}$ inch in diameter (2.3 mm.).

Dr. Coe marked a number of clams at La Jolla and replanted them. In collecting these marked individuals at later dates he was able to make a number of observations concerning their growth and development. He gives two main reasons for the slower growth during the winter months; first, the storms, heavy surf, and shifting sand which interfere with continuous feeding; and second, the reduction of the available food supply at that season. He attributes a decreased rate of growth in August when the temperature is the highest and the seas invariably the most calm, to the requirements of the reproductive system and the acts of spawning. This decreased rate during August is frequently marked on the shell by a dark colored band or "growth ring."

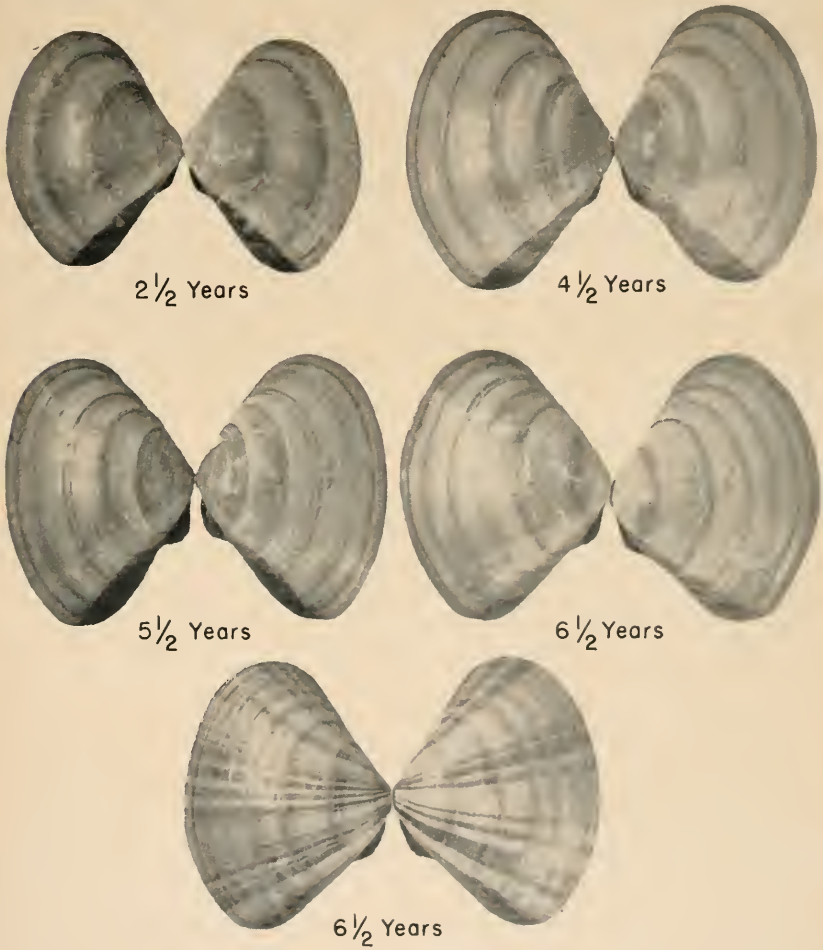

FIGURE 119. Growth rings on several different clams from Morro Bay. Each light and dark ring counted together represents one year of growth. Clam shells from most beaches are not so clearly marked as those from the Morro Bay area. This picture illustrates the extreme variation in the growth rate of individual clams. Even though there is a variation of four years in the ages of these clams they are all approximately the same size. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

Rings

The shells of many individuals are marked by concentric rings of alternately darker and lighter coloration. At irregular intervals the general opacity of the shell is interrupted by translucent rings which can be seen on fresh shells (particularly clams less than five years of age) by holding the shell to a strong light somewhat in the same manner as one would candle hens' eggs. Both minor and major rings may be formed on the shell of an individual clam at any season of the year. In most cases the rings result when the clam is disturbed, causing interruption of feeding and withdrawal of the mantle from the edge of the shell. When feeding is resumed, the mantle is again extended, and secretion of the shell continues. Since the mantle, when re-extended, seldom aligns itself to the identical previous margin the new shell is not directly continuous with that previously deposited but underlies the latter and projects beyond it forming a slightly raised ring. The color of this new portion may differ conspicuously from that of the adjacent portion of the shell. Thus the growth ring used in age determination is usually formed in the fall or winter months when the clam is subjected to the greatest prolonged period of disturbances, or during the spawning period.

Many clams form rings when they continue growth after an injury (frequently the result of a clam fork piercing the mantle). This injury ring may appear on the shell as either a heavy circular ring parallel to the growth rings or as a disfiguration with a radiating scar running from the point of injury to the margin of the shell. Frequently, examination of the mantle of these injured clams will reveal seed pearls inbedded therein. These pearls are of no commercial value and are often so small

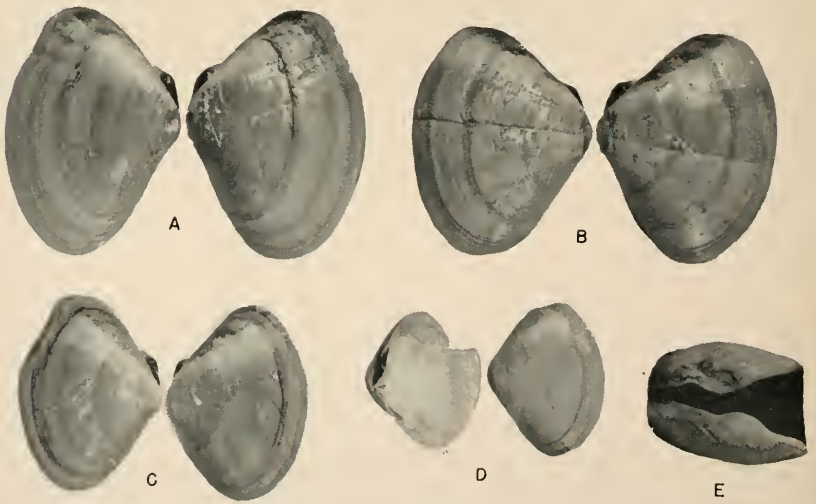

FIGURE 120. Injury rings and shell scars resulting from injuries. The rings and scars always appear at the point of injury to the clam. Part of the shell of the smallest clam (D) has been broken away to illustrate manner in which the new shell grows. Clam E illustrates shell which bent under so that both valves overlapped. Scratches in periostracum of B and C are either from clam forks or some other digging implement. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

as to be difficult to observe. As many as seven of these small pearls varying from 0.5 to 2 mm. in diameter have been found in the mantle tissue of one injured clam.

REPRODUCTION

Sex

For many years it was the general belief that the Pismo clam was hermaphroditic (producing eggs and sperm from the same gonad); however, recent studies have demonstrated that this is not true. The Pismo clam is unisexual with the proportion of males and females about equal. In a few cases hermaphroditic Pismo clams have been found. In all cases these ambisexual individuals were in their first spawning season and the gonads were predominately one sex with only a few follicles of the opposite sex present. The sex of a clam cannot be determined from the outside, but requires careful study of the tissues with the aid of a microscope.

Maturity and Spawning

Nearly all Pismo clams become sexually mature after they have lived through one winter. On most of the beaches during the spawning period these one-year-old clams range from about one to two or more inches in diameter. The smallest mature spawning individual observed by the author was about three-fourths inch in diameter. In May the males usually have a few thousand motile spermatozoa and the females some nearly mature ova. During June and July the gonads increase rapidly in size and the proportion of mature gametes or sex cells becomes larger as the first spawning period in late July or early August approaches. The mature gametes are probably discharged by the individual clam when there is a fair rise in the temperature of the water. (This can be effected artificially by taking clams from the ocean and placing them in an aquarium where the water is just a few degrees warmer than that from which they have been removed.)

Emission of gametes particularly by a male, stimulates the concurrent spawning of the other individuals of both sexes in the immediate vicinity. This is obviously a necessity in order to insure fertilization of the millions of eggs released by each female. Each clam experiences several spawnings during a season as only a portion of the gametes ripen at one time. Residual gametes which remain at the end of the spawning season are reabsorbed later. While the clam is ripe and in a spawning condition the flesh is usually whitish in appearance; after spawning has been completed the flesh takes on a dull buff color.

Eggs

The eggs of the Pismo clam are very small, measuring about $^1/_{350}$ of an inch in diameter when mature. In several clams examined there were found to be around 10,000,000 to 20,000,000 or more eggs per individual with an average of 15,000,000 or more eggs in clams five inches in diameter. The 1949 annual Pismo clam census conducted at Pismo Beach by the Bureau of Marine Fisheries indicated that there is an average of 150 mature clams for each six-inch wide strip of beach taken from the high tide line to the water's edge on a minus 1.2 foot tide. Assuming half of these clams were females, and since about 90 percent of these females were over three inches in diameter they probably spawned around 15,000,000 eggs apiece. (A three-inch clam would probably spawn about half

as many eggs as would a five-inch clam. The 15,000,000 egg estimate used here was figured as an average for the clams above three inches in diameter at Pismo Beach in 1949.) In the 9.4 miles of clam producing beach there would have been somewhat over 112 trillion eggs spawned. [75 (female clams) × 2 (6-inch wide strips) × 5,280 (feet per mile) × 9.4 (miles to the beach) × 15,000,000 (eggs per female clam).] It has not been determined how many five-inch clams laid end to end it would take to encircle the world but if all the eggs spawned in one year on Pismo Beach matured into legal clams there would probably be a sufficient number to perform this feat.

Larvae

Practically nothing is known about the early life of the Pismo clam from the time the eggs have hatched into free-swimming larvae until the young clams appear on the beach. The earliest that young clams have been found on the beach at La Jolla is five months after the first spawning takes place. At Pismo Beach this period of time between first spawning and first finding of the new set is 12 months. What happens in between is a mystery. As in related forms (oysters, mussels, and some other clams) the fertilized egg hatches into a free-swimming larva in a few hours. These larvae which in no way resemble the adult are free-swimming for a period estimated as at least several weeks. At the end of the free-swimming period they settle into the sand and develop into young clams. Theoretically, with ocean currents along our coast moving at the rate they do, free-swimming clam larvae could be swept coastwise for a distance of 40 to 100 miles in 20 days.

The young clam upon setting digs into the sand a fraction of an inch and anchors itself by means of a fine thread called a byssus. The byssus usually has a number of sand grains attached to its distal end which improves the anchorage of the young clam in the constantly shifting bottom. This byssus is degenerated within a few months as the clam becomes more able to care for itself. As stated in a previous paragraph the smallest clam ever found was 2.3 mm. in diameter. It is not known at what size the clam transforms from a larva, but it is presumed to be much smaller than the 2.3 mm. individual.

MORTALITY

Larvae

As already pointed out a three- to six-inch female clam is capable of producing between 10 and 20 million other clams per year; however, the number of clams available on any beach indicate that not more than a small fraction of 1 percent of these eggs ever become mature clams. The 1949 annual census showed only one clam of the 1949 year class in three strips each six inches wide. Using the same formula which was used to obtain the number of eggs spawned, one would estimate somewhat more than 33,000 clams of the 1949 set on the entire 9.4 miles of beach. The 1948 annual census indicated that there were more adult clams then than in 1949. It would probably be safe to estimate that 120,000,000,000-000 eggs were spawned in 1948. That only 33,000 clams resulted from this 1948 egg count is startling to say the least. The 1949 set was undoubtedly an extremely poor one but it is easy to see from these figures the

mortality which must take place during the period between spawning of the egg and transformation into a young clam.

Since practically nothing is known of the Pismo clam during its larval period it would be difficult to assign any particular cause to this mortality rate. It is known that with comparable species sudden changes in temperature of just a few degrees are usually fatal. Likewise changes in salinity would affect these free-swimming larvae, they could be washed ashore by the turbulent surf in which they live or, on the other hand, they could be swept offshore or to some beach where conditions were unfavorable for their development. Most of them probably fall prey to the plankton feeding fish and invertebrates which inhabit the same environment. More or less continuous spawning by the adults over a period of several months is reasonable assurance that not all of any particular year class will be wiped out by any one factor before they have a chance to set.

Post-Larvae and Adults

Environmental Factors—Once the clam has set, changes in temperature and salinity probably do not have as much effect on its life as similar changes would have on the free-swimming larvae, but pronounced changes will undoubtedly increase mortality. Frequently clams will be found in large numbers around the mouth of a river during dry years when there is no water flowing in the river. As soon as enough rain falls to obtain a runoff and this fresh water breaks through into the sea the clams for as much as a mile in each direction away from the mouth are affected and most of them die. For this reason mature Pismo clams are seldom found near the mouth of a flowing river.

Oil and other pollutants when they are present play an important role in the mortality rate of the clam. Due to strict laws regarding pollution and rigid enforcement of these laws, this is not a great problem at present. Perhaps dinoflagellates, which when present in sufficient numbers discolor the ocean and are known as "red tide," could be considered a pollutant. There have been instances where the occurrence of this red tide was presumed to be responsible for the resultant loss of hundreds of thousands of young clams. In these cases the larger clams were unaffected. These dinoflagellates have been found to cause mussels and some clams to be toxic or poisonous during the summer months when the "red tide" is prevalent. There have been no reported fatalities to humans from eating Pismo clams at these times, but, there are a number of authentic records of animal poisoning (cats and dogs) from eating the trimmings from clams when these dinoflagellates were present. It is recommended that when cleaning Pismo clams during summer months the dark colored liver as well as the intestine be removed and discarded and not fed to the family pet.

There is at least one case where extreme cold resulted in a terrific loss to the clam population. On this occasion at Pismo Beach an extremely low tide left the sandy beach exposed for several hours during subfreezing weather. The wet sand froze to a depth of over an inch and most of the small clams in this zone became inactive. When the tide came in these inactivated clams were washed out of the sand and onto the beach where they had no chance to recover and the gulls had a feast.

During some months of the year, particularly in the winter, the heavy incoming tides often cause so much shifting of sand that many

of the older clams in deep water are washed free. They are bounced shoreward as each succeeding wave breaks and tons of water roll to the beach. At Pismo Beach just one of these massive breakers rolled a six-inch clam 70 feet toward shore. Whenever this type of tide is running many thousands of very large clams are left stranded high and dry. On presumably barren beaches, offshore beds of legal sized clams can be located by finding these large clams lying exposed at the high tide line.

Natural Enemies of the Pismo Clam—Gulls, sharks, rays and some surf fishes such as the corbina probably all account for a fair number of young clams each year. Some rays are known to practically denude a clam bed by using their "wings" to set up a suction which pulls the clam from the sand somewhat in the same manner as a plumber's helper clears the drain of a kitchen sink. Once the small clams have been sucked out of the sand by this process it is a relatively simple matter for the ray to pick up, crush and swallow them.

The gulls have a system all their own for opening live clams up to three inches or so in diameter. It is not an unusual sight on Pismo Beach during any good low tide to see half a dozen gulls carrying clams into the air in their beaks and dropping them from a height of 50 feet or more onto the hard packed sand. It does not take many of these drops before the clam shell either shatters or the adductor muscles break, opening the two shells and exposing a juicy tidbit to the ambitious gull. On the same beach a goodly proportion of the clams left exposed by previous diggers are run over by cars. The weight of the car causes the clam to burst and again the gull enjoys a tasty meal. Gulls also devour vast numbers of clams up to three-fourth inch in diameter. These are swallowed whole

FIGURE 121. Top row, moon snails (*Polinices* sp.). Center and bottom row, young Pismo clams showing typical cone-shaped drill holes near the umbo (favorite spot for boring activities of moon snails. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

and the shells regurgitated a number of hours later when the soft parts of the clam have been digested in the bird's stomach.

Another natural enemy which accounts for its share of clams up to at least two years of age is the moon snail, *Polinices* sp. These snails drill a hole in a clam (usually near the umbo) with a rasping tongue or radula. The hole in a drilled shell is cone-shaped with its greatest diameter on the outside, tapering slightly as drilling progresses. As soon as the hole is completed the snail inserts its tongue and licks out the soft flesh of the clam. On many beaches one of these drilled clams can be found to about every eight or ten feet of beach. Considerable research has been done on the oyster drill, *Urosalpinx cinerea*, a snail which feeds on oysters. They have been observed drilling oysters with a frequency of as much as 60 strokes of the radula per minute at 77 degrees F. Apparently they use no chemical solvent in this drilling process though some snails are credited with chemical boring rather than mechanical. It is not known how long it takes *Polinices* to drill a Pismo clam, but *Murex* another drilling snail is credited with boring an average sized oyster in five to seven days. *Urosalpinx* has been known to drill an oyster 1½ inches in diameter in two days, a 2½-inch oyster in four days, and a four-inch oyster in seven days.

The several species of cancer crabs (*Cancer* sp.) which live in the same habitat also kill and feed upon Pismo clams. The shells of clams up to an inch in diameter are cracked in the crab's front pincers. The meat is then removed from the shell and consumed by the crab.

The only evidence of parasites in Pismo clams is the presence of an occasional fluke or trematode. These are generally found imbedded in the tissues of the clam. Their effect upon the clam is not usually serious, although they do interfere with the clam's sexual development. They are in no way harmful to man. About one-third of all large clams examined had from four to a dozen or more colorless cysts, each containing one trematode.

It is entirely possible that one may upon occasion find a small pea-sized, whitish-colored crab living inside the clam. To the author's knowledge none have been reported from Pismo clams to date, but, this is no indication that they do not live in them. These crabs have frequently been taken from mussels, Washington clams, gapers, and several other species of clams. In 1949 one of these commensal crabs was found in a razor clam which was taken on Pismo Beach. They are in no way harmful to the clam but live within the mantle cavity where they are protected from enemies which might feed upon them should they not have the living clam to use as a home. These crabs are so unusual that any found should be preserved in alcohol and turned over to some scientific institution.

The shells of clams on certain beaches nearly always show from one to several bright red blotches or streaks just beneath the periostracum. Sometimes there may be deep yellow blotches on the same clam. The origin of these red or yellow marks is unknown. They usually radiate away from a small break in the periostracum. It is felt that they may be caused by some bacterial action or possibly by some chemical present in the water on those particular beaches. They may even be due to some parasitic worm.

FIGURE 122. Aerial view of part of the crowd of cars and clam diggers on the five and one-half mile stretch of Pismo-Oceano Beach which had formerly been closed to digging for over 20 years. It is estimated that 5,000 or more diggers a day removed limits of clams from this beach during the first few months after it was opened in October 1949. The dark spot in the middle distance is a sand bar. *Photograph by McLain Studio of Photography, San Luis Obispo, November 1949.*

The Effect of Man (California)—The direct effect of man on the mortality rate of the clam is undoubtedly high, particularly where the large clams are concerned. Regardless of how much man contributes toward the mortality of the clam, he is the only one of the many factors mentioned (with the possible exception of pollution) which can be controlled to any extent. In the years for which we have a record of landings and during which commercial digging of Pismo clams was allowed (1916-1947) nearly 100,000 pounds of clams were reported as taken each year by commercial diggers alone. In 1918 commercial diggers made their greatest landings, nearly 670,000 pounds. At an average weight of about two pounds for a legal clam this represents a yearly average of better than 50,000 clams and a peak year of 350,000. These are clams taken from California beaches only. During the period from 1916 through 1947 commercial diggers in California, took some $6\frac{1}{4}$ million pounds of clams, nearly all from Pismo Beach and Morro Bay. This $6\frac{1}{4}$ million pounds represents only those clams for which landings were reported. In all likelihood this figure should be considerably higher.

FIGURE 123. Some of the several thousand diggers who flocked to the recently opened clam sanctuary at Pismo-Oceano Beach. Note the thousands of clams left lying where they were dug. About half of these clams will be washed high and dry on the beach by the waves of the next incoming tide. The law states that the clam must be returned either to the hole from which it was dug or to deep water. Just about everyone in this picture is violating the law. *Photograph by Rod Johnson, San Luis Obispo, January 1950.*

The noncommercial digger (sportfisherman) has probably contributed even more to the losses incurred in the Pismo clam population. During one weekend before the opening in 1949 of a previously protected area, noncommercial clam diggers were checked off Pismo and Morro beaches at all exits. Over 37½ tons of clams accompanied these clammers. Probably twice as many undersized clams were left exposed by the carelessness of these diggers. Most of these exposed clams are washed high and dry by the incoming tide and die in a relatively short period of time in the sun the next day. In 1949, the Le Grande clam sanctuary, a section of beach four miles long located a few miles south of Pismo Beach, was opened to digging after a closure of 20 years. It is estimated conservatively that in the first two and a half months after the opening some 50,000 clams per day were removed by noncommercial diggers. During this 2½ month period some 2,000,000 clams (4 million pounds) were taken from this beach. Many thousands more would probably have been taken if it were not for poor tides and consequently poor clam digging for at least 10 days each month. Where Pismo Beach had been supporting some 5,000 diggers a month, the opening of this area drew more than 5,000 diggers a day on many days. It is not too difficult to imagine that with a clamming pressure such as was exerted here, there would not long remain a single inch of unturned sand. Presumably that is what happened as it is believed that six months after the opening of this beach not many legal

FIGURE 124. Undersized clams left stranded by the tide on a short stretch of Pismo Beach. This is the result of leaving the clams lying where they are dug. These clams are alive and healthy but a few hours in the hot sun and the gulls will enjoy a feast. *Photograph courtesy of the Pismo Beach Chamber of Commerce.*

clams remained. Untold thousands of undersized clams were either severly injured by clam forks or left exposed on the sand to be washed ashore by the incoming tide, there to die.

From the annual census work conducted by the Bureau of Marine Fisheries from 1923 through 1941 and 1947 through 1949 a mortality rate was determined for Pismo Beach. Fifty-five percent of the clams died in their first year; 45 percent of the remainder died the second year, and 29 percent of the balance died the third year. The fourth year the mortality rate jumped to 34 percent as a few "just a wee bit too small but I'll take it anyway" clams, along with some which had attained legal size, entered the catch. The next three years as even more clams attained legal size the mortality rate jumped to 52 percent, 68 percent and 72 percent respectively. Table 1 puts this mortality rate into figures.

In other words, where 1,000 clams start out in life, only five remain alive at the end of seven years. How much of this mortality is directly attributable to man is difficult to determine. It would probably be safe to state that about three-fourths of the mortality of Pismo clams over three years of age in California is due directly to man's activities.

FISHING METHODS

Locating and Digging

Probably the most important method of collecting Pismo clams is with a six-tined potato fork. The digger picks a locality on the beach which to him looks suitable; this may be any place from exposed sand flats to four or five feet of water at low tide. Working backward in a line parallel to the edge of the water he probes with the fork until he strikes a

FIGURE 125. Over one million clams (2,000,000 pounds) wasted on slightly more than four miles of beach in the Le Grande section south of Pismo Beach. None of these clams had to die. All of them did die. This unnecessary destruction of a natural resource is the result of noncommercial diggers (holders of sportfishing licenses) failing to observe the law and replace the undersized clams in the holes from which they were dug. Most of the clams in this picture are over four inches in diameter and would have attained legal size within a year. When thousands of diggers are on the beach, all of the Fish and Game wardens in the State would be required to enforce the law. Only when public opinion becomes sufficiently aroused will such wastage come to an end. *Photograph by John E. Fitch, February 1950.*

TABLE 1

Age of clams	Number of of clams	Percent loss	Number clams lost	Number clams remaining
½ year	1,000	55	550	450
1½ years	450	45	202	248
2½ years	248	29	72	176
3½ years	176	34	60	116
4½ years	116	52	60	56
5½ years	56	68	38	18
6½ years	18	72	13	5
7½ years	5			

clam. The clam is then dug, measured and if legal placed in a sack snapped to a belt at the waist. If undersized it is returned to the water. Reasons for working parallel to the edge of the water are twofold; first the broad side of the clam is presented to the probing fork and there is a much greater chance of locating the clam; and secondly, the digger can keep an eye on the breakers offshore and be prepared to brace himself when an unusually heavy one strikes. Throughout the years a number of clam diggers have been drowned after being swept from their feet by these heavy breakers while working in deep water. The weight of a sack of clams and some heavy water-soaked clothing were sufficient in these

FIGURE 126. Some of the cars leaving the beach at Oceano after successful clamming, other cars bringing diggers to the beach cause a traffic jam at the wooden ramp which is suitable for one way traffic only. It is safe to assume that every digger in every car leaving the beach has his full limit of claims. Car tracks which continue in the right foreground go to the wooden ramp at Pismo Beach which is the only other good entrance or exit from the beach. *Photograph by McLain Studio of Photography, San Luis Obispo, November 1949.*

cases to keep the digger from regaining his feet. The snap on the sack is another safeguard against just such an occurrence.

A second method of obtaining Pismo clams is to use a rake which may be made by bending the tines of a heavy pitchfork and extending the handle several feet. A rope attached to the fork is looped around the waist and with the long handle resting on his shoulder the clammer walks backward dragging the tines through the sand. When a clam is struck it can be turned out by lifting the handle of the rake to an upright position.

A modification of this method has been employed in deeper water beyond the breakers. In this case a much longer handle is used and the rake is towed behind a rowboat or small skiff. When a clam is struck a third member of the party dives overboard and follows the handle of the rake down until the clam is located. Most of the clams in this deeper water are of legal size so on most of the dives another clam is added to the bag. Frequently, however, the surge of the swells breaks the fork loose from the bottom and the clam cannot be located by the diver.

A method just coming into popularity in Southern California is that employed by skin divers. Here a paddle board is paddled along just beyond the breaker line, the skin diver lying on the board watching the bottom through a face plate. The clams are located by seeing the siphons at the surface of the sand. A quick dive, and the clam can be easily turned out of the sand with a short digging bar of home design. For amateur skin divers who wish to employ this method let it be stated here that the spiracles on a buried sting ray quite closely resemble the two siphons of the feeding clam. Many of these older clams which are found in water 10 to 35 feet deep have a fair portion of their shell sticking above the bottom making them easier to locate.

If a person is entirely without digging implements and finds himself on a good clam beach he can still find clams by employing his feet in conjunction with the wash of the waves. Moving the feet back and forth while standing in one spot washes away the sand and leaves the clams exposed. On some beaches too, Pismo clams may be discovered by walking along the exposed flats or in a few inches of water looking for the hydroid colonies which are frequently attached to the siphonal end of the clam and show above the surface of the sand.

Perhaps one of the most novel methods to have been used in obtaining Pismo clams was the employment a number of years ago of a commercial diver who wore a diving suit and helmet equipped with an air compressor. His job was to gather the legal clams which were to be found in the deeper water beyond the breakers. Since he was not employed for very long it is assumed that this method was a failure at least from a commercial standpoint.

FIGURE 127. Occasionally a plane lands on the beach, the pilot climbs out, puts on his clamming gear, digs his limit of clams and flies away. Some of these planes travel several hundred miles round trip to obtain clams during a particularly low tide. *Photograph by Kramer A. Adams, November 1948.*

During some times of the year and on some beaches, clams can be located on the exposed flats and sand bars by looking for either holes or mounds of sand at the surface. Both holes and sand mounds are made by water forced out through the siphons when the clams dig deeper after the tide has left that particular place exposed.

Replanting Undersized Clams

Under the present law all undersized Pismo clams must immediately be returned to the hole from which dug or to deep water. This law is necessary to insure a future crop of Pismo clams.

Perhaps the easiest method of complying with this law is to dig out a forkful of sand, place the undersized clam in the resulting hole and then replace the "divot." Clams buried in this manner should be so placed that the dark knobby hinge ligament is up. In returning clams to deep water the recommended method is to throw the undersized clam into water which will be at least waist deep at low tide.

PREPARATION

Opening

One problem that has faced many clammers at one time or another is, "just how do I get this darned thing open?" There are several methods of opening Pismo clams, probably the most popular of which is to open them alive with a stiff-bladed knife. If the clam is allowed to lie undisturbed for a short period of time it will usually open its shell a fraction of an inch and by some fast maneuvering with a knife one of the adductor muscles can be sliced in two. Once this one muscle is cut the clam is not able to close tightly and the other muscle can then be cut, allowing the shell to gap freely. At this point the clam can be placed under a fast running faucet and all sand washed out. At no time before cutting the muscles should an attempt be made to rinse in fresh water as the clam will "shut tighter than a clam" the second the fresh water strikes it. Opening should be done in a flat shallow pan so that the juices which run out can be saved and used in broth or chowder.

As an alternative method, one can place the clams in a large container which has some water in the bottom. A lid is placed over the container and the whole set on a lighted burner. In a short time the clams are steamed open, the meat can be removed, sand rinsed off under a fast running faucet and the juice in the bottom of the cooker saved for future use. The sand can readily be strained from this juice.

If the clams are desired raw and opening with a knife while the clam is alive does not prove practical, the clam may be placed in the freezing compartment of a refrigerator for an hour or so. As soon as the clam freezes, the muscles relax and the hinge ligament forces the shell to gape open. A knife can be used on these gaping clams without danger of it slipping and cutting the wielder.

Many people believe that if Pismo clams are placed in a tub of fresh water and some cornmeal is added that these clams will purge themselves of sand, feed on the cornmeal and be ready for the frying pan when removed. This is not true; placing salt water clams in fresh water only causes them to close tightly and eventually they will die. If placed in fresh sea water they will purge themselves in time but the sea water must be changed often. It is much more practical to rinse the clam under a faucet to remove the sand.

Removal From Shell

When a clam has been steamed it opens of its own accord and the meat usually will fall out or can be picked out. Sometimes when this method is employed the meat sticks to the shell at the attachment of the

two adductor muscles. This can be scraped free with either a thin-bladed kitchen knife or with the thumbnail.

In a clam which has been opened raw by cutting through the two adductor muscles a thin-bladed knife should be inserted between the mantle and the inside of the shell. With this the mantle is easily lifted away from the shell and the meat is then held in the shell only by the adductor muscles. These muscles are sliced through next to the shell and the clam usually falls out without further prompting.

Trimming

Many people do not discard any part of the clam before using it as a food and if a person is not a finicky eater there is nothing wrong with this method. For those who wish to enjoy their clams to the utmost or wish to try them in other ways than just chowder a certain amount of trimming can be done. First, if the clam has been opened raw the now four "buttons" (sliced adductor muscles) should be removed. Next the siphons, mantle and gills are trimmed off leaving only the foot. The marble sized dark mass of liver can be removed with the thumbnail and discarded. The hard digging side of the foot should also be trimmed off (these trimmings are added to the mantle, siphons, etc. pile). Frequently the color of the outer portions of the foot is dark brown in contrast to the usual pinkish color found in most clams. Clams which have a dark colored foot are healthy and normal and this meat, even though dark in color, should not be thrown away. When finished trimming one should have left a section of the soft base of the foot about the diameter of a silver dollar. This piece can then be sliced through lengthwise. The intestine is revealed by this last slicing of the foot and can be easily picked from the tissue with the fingers and discarded. This leaves three piles, one containing the four buttons, a second the two pieces of foot, and the third containing all the trimmings.

Use as Food

Rather than attempt giving recipes for the cooking or use of the Pismo clam it seems desirable to outline the general usages and let the individual obtain his favorite recipes from a standard cook book. The milky juice which resulted from opening the clams may be used in any of several ways. First it may be used as a drink just as it is, or it may be put in with the chowder to add flavor or it may be heated and used alone as a clear broth.

The buttons are excellent as a seafood cocktail. They are usually not cooked when prepared in this manner. Cocktail sauces may be added to suit the individual's taste.

The two dollar-sized pieces of the soft foot are perfect for frying. Some individuals prefer these parts fried just as they are, others demand that they be rolled in flour, cornmeal or cracker crumbs and egg batter before being placed in the pan. They are excellent garnished in any manner.

Finally the trimmings may be ground or chopped up and used as clam chowder, clam croquettes, deviled clam, clam dressing (for stuffing turkeys, chickens or ducks), clam spaghetti, or any of dozens of preparations. Many people prefer to eat their Pismo clams raw just as they are; others who do not care for raw or fried clams may wish to use the whole

clam in preparing chowder. Any number of modifications or improvements are applicable to the above suggestions.

Miscellaneous Uses

Pismo clams have been used for human consumption for several hundred years at least and probably as far back into history as man has been roaming the Pacific Coast. Indian kitchen middens at a number of localities, along the coast of California and Lower California contain shells of the Pismo clam which the Indians gathered and used. The shells of these clams were also utilized by the Indians to a certain extent, primarily as ornaments but probably also as household aids for digging or scraping.

The earliest records of the State of California indicate that on many of our beaches from Pismo Beach to Imperial Beach teams of horses and plows were used to harvest this clam. The clams plowed out were loaded in wagons and hauled away to be used to feed hogs and chickens. Early laws effected to protect the clam were extremely liberal but at least they did cut out this wanton destruction of a wonderful natural resource.

The present day use of Pismo clams is confined to utilization primarily for human consumption. Of lesser importance is the use of these clams for fish bait by the many surf fishermen along our coast. Use for fish bait is perfectly legitimate if the clams are legal sized, if the fisherman has a valid fishing license and if he does not take more than his allowable limit. This is seldom the case, for investigation has revealed that very few surf fishermen who use Pismo clams for bait do so legally. Countless thousands of small clams are destroyed each year by these fishermen either in their ignorance or defiance of the law.

Many people who visit the California coast and see the Pismo clam for the first time marvel at the size of the shell and wonder to what use it can be put. Probably the most common usage for these massive shells is as ash trays and few are the homes along the coast where they have not served as such at one time or another.

The shells have not proved satisfactory for button manufacturing and no other large scale commercial utilization is made of them at present. It does seem as if there would be some commercial product (calcium meal or such) that could be made from these shells. Perhaps at some future date this thought will be realized.

There has been a certain amount of canning of Pismo clams, particularly those taken in Mexico which are shipped into the United States. This has proven quite unsatisfactory because of several factors. The expense of digging the clams on the Lower California coast is quite low (one man can gather and shuck enough clams at one low tide to produce from one to two hundred pounds of meats). However the expense of getting them to the cannery is considerable. Transportation is difficult whether by land or water, refrigeration is always a problem but the sand included with clams shucked on the beach seems to have been "the straw that broke the camel's back." The canned Mexican Pismo clams just have not compared in quality of the pack with the other kinds of clams canned in the United States.

During the few years that shipping Pismo clams from Mexico was popular the amount shipped to California was the equivalent of somewhat over 83 million pounds, live weight. The highest poundage sent in during

any one year was in 1945 when nearly 5¾ million pounds were taken in Lower California and shipped to California. One can obtain an idea of just how high this figure is when compared with the total California commercial landings for all of the years from 1916 through 1947 of about 6¼ million pounds. The greatest yearly take of California clams was in 1918 when 666,000 pounds were gathered by commercial diggers.

There is at present a limited tonnage of Pismo clams shipped from Mexico to Pismo Beach where they are used by the restaurants. Such shipments became necessary when a law forbidding the sale of California Pismo clams was passed in 1947. The demands of the traveling public for the dish which made Pismo Beach a nationally famous eating stop were instrumental in forcing the restaurant owners to seek a new source of supply. Not all of the Pismo clams now sold in the restaurants at Pismo Beach are shipped from Mexico. There exists today and probably always will exist some blackmarket trade in locally dug Pismo clams. The incessant activities of the fish and game wardens do much toward keeping this to a minimum.

MANAGEMENT

Pismo Clam Program of Investigation

In 1917 the California Fish and Game Commission inaugurated a program for the scientific investigation of the commercially important fishes of the State. This program was worked out and developed by Dr. William F. Thompson. It provided for the study of the commercially important fisheries of the State for the purpose of developing regulations which would permit the greatest use of these natural resources without destroying the future supply.

In accord with this general program the commission in 1919 obtained the services of Dr. Frank W. Weymouth for the study of the Pismo clam fishery of California. This mollusk was selected for investigation as it was representative of a California bivalve of considerable commercial importance and was apparently experiencing a decided depletion, as evidenced by the demands for increased protection. Dr. Weymouth began the study of the Pismo clam fishery in 1919 and in 1923 published his results. In this work Dr. Weymouth laid particular emphasis on growth physiology and proved that the age of the clams could be determined from the annual rings. He also made a study of the life history and of the fluctuations in abundance of different year classes. At the conclusion of his report he made a number of recommendations including one that, in order to follow the actual conditions of the species, in addition to the collection of the data on the commercial shipments, a census of the young by the method of cross-sectioning the beach be carried out at least once each year. Through this recommendation the annual Pismo clam census at Pismo Beach came into being in 1923 and, except for the war years from 1942 through 1946 when the staff of the Bureau of Marine Fisheries was inadequate to accomplish the task, it has been carried on ever since.

Annual Pismo Clam Census

The accessibility of these clams to sampling and the relative immobility of the individuals have made the population particularly susceptible to a quantitative study. This annual census consists of digging a trench six inches wide commencing just below the high tide line and extending

seaward as far as is feasible on a good low tide. These sections are taken at three different localities on Pismo Beach, each separated from the other by several miles. Commencing at the vegetation line where the sand dunes are found, a rope is stretched seaward. This rope is conspicuously marked every three meters into segments. Commencing at the vegetation line and proceeding seaward these segments are numbered serially. The segment number reached by the highest wave of the previous high tide is recorded

FIGURE 128. Members of the staff of the Bureau of Marine Fisheries, California Division of Fish and Game, conducting the annual census. Wooden trays are to screen sand for small clams. Clams removed from each three-meter segment are tied in cheesecloth for later aging. Notebook is for keeping track of segment number, number of clams and other pertinent data. *Photograph by Kramer A. Adams, November 1948.*

for each of the sections. When in the digging of any particular segment a clam is encountered, the segment number is recorded as is the number of clams taken from that particular segment. The clams from each segment are tied in cheesecloth with a label enclosed giving the segment number, section number and the number of clams in that segment. These clams are measured and their age determined, then returned to the water (most clams if not injured can be kept alive and healthy in a moistened sack for several days).

It is felt that this census which is made at definitely located points on the various beaches usually during November will give a representative cross-section of the clam population in that part of the beach. In addition, the data gathered during this census have been used to study, (1) the effects of dominant year classes, (2) over fishing, (3) selective fishing, (4) the success of spawning seasons, and (5) mortality. In the former closed portion of the beach the mortality rate determined from the annual census even shows the effect of illegal commercial clam digging operations. Most of this illegal digging took place at night and was practically impossible to check. The sudden sharp increase in mortality at age five when some of the clams reached a legal five inches in diameter and the even greater increases at ages six and seven proves beyond any doubt that this poaching took place.

Planting

Planting of Pismo clams on beaches from Washington to the Mexican border has been attempted sporadically at least since 1900. Most of these plantings have been made in an attempt either to establish clams on beaches where they never before existed or to reestablish a population where the native stock has been depleted. None of the clams planted north of Monterey Bay have ever established themselves. A few clams were found at Crescent City several years after a plant was made there in 1903, and presumably these were clams from that particular plant.

Most of our sandy beaches south of Halfmoon Bay do have a native population of clams. In a number of cases we know this only from the shells which occasionally wash up on the beach. Through the free-swimming larval stage it is felt that any beach within a 50 mile radius of a clam-bearing beach would be populated if conditions were favorable for the Pismo clam to establish itself. The public has long felt that planting clams on a particular beach would in time establish a good population where only a poor one existed prior to the planting. Contrary to popular opinion, planting large clams (or any clams) on a beach frequently has the opposite effect. No plants of clams can ever be kept secret for very long, and, as soon as the word gets around, the public turns out en masse in search of these clams. Not only are the clams which were planted removed, but most of the former poor supply of native stock is also taken and the beach is left more barren than ever. Even if the clams are protected by local or state laws they are not safe from the public, as is illustrated by the raiding of the Scripps Institution of Oceanography beach at La Jolla in 1948. This beach is a part of a marine natural preserve and is protected by state law. Nevertheless, when a private citizen "found" some large clams on the beach there he brought a jeepload of diggers to help remove them. These clams which he "found" were the marked individuals which Dr. Coe was using in his growth rate studies.

In any event the most that can be accomplished by planting clams on any beach is that the planted clams will survive and eventually grow to a legal size. Considering natural mortality it is not probable that more than 200 clams out of 1,000 one- or two-year old clams would ever reach legal size. It is not felt that the spawn from any planted clams will greatly help to repopulate that beach. Environmental conditions (shifting sand, coarse sand and shells, pollution, etc.) are probably the factors which are responsible for keeping the clam population of any beach at a low level. The very fact that there is a free-swimming stage in the life cycle of the clam is the best chance for its establishment on any particular beach should conditions become acceptable on that beach.

A partial list of plantings which have been made since 1900 is presented to show when and where various plants were made. This list is as

TABLE 2

Partial List of Plantings

Year	Number of clams	Locality
1900 and 1903	600	Just south of the Salinas River mouth
1903		Crescent City—clams died en route
1903	1,000	Crescent City
1914	ca. 400	Pebble Beach, Carmel Bay
1915	ca. 1,000	Beaches between San Simeon and Cayucos
Sept. 1934	ca. 8,000	Between Carpinteria Beach and Huntington Beach
Oct. 1934	ca. 2,100	Between Brighton Beach, Terminal Island and Seal Beach
1935	ca. 900	San Clemente Beach
1936	ca. 460	San Clemente Beach
1937	over 1,000	Huntington Beach
1938	450	Planted from Belmont Pier near Long Beach
1939	150	Planted from Belmont Pier near Long Beach

complete as available data permits; however, it is known that other plants have been made including some on Oregon beaches and perhaps a few in Washington.

Legislation

A chronological history of the laws relating to Pismo clams is presented to show the changes that have taken place over a period of years Some of these changes were made to simplify former laws, but most of them, were made in an attempt to conserve the Pismo clam in California. No attempt will be made to analyze these laws or the effect their enactment has had upon the Pismo clam. Prior to 1911 there were no laws in effect on the Pismo clam. In addition to these laws which affect Pismo clams taken in California there are laws governing the importation of clams from Mexico. The principal law regarding these states that they "may be imported into this State when accompanied by a United States Custom House entry certificate showing place of origin, and a certificate of clearance from the responsible governmental agency to the effect that such shipment is made in compliance with laws and regulations of the place or country of origin." Such Pismo clams may be canned in California and shipped outside this State.

Since these laws are subject to change at any time they should not be taken as the final word. To obtain up-to-date information one should get in touch with the nearest office of the California Division of Fish and Game.

TABLE 3

Laws Relating to Pismo Clams

Year	Minimum size limit	Bag limit	Remarks
1911	13 inches circumference (about $4\frac{7}{8}$ inches diameter)	200	License required for sale of Pismo clams.
1915	12 inches circumference (about $4\frac{1}{2}$ inches diameter)	50	
1917	$4\frac{3}{4}$ inches diameter	50	Districts 15, 16 and 17 roughly Monterey Bay between Pigeon Point and Yankee Point open only between September 1 and April 30 each year. All other districts open the year around.
1921	$4\frac{3}{4}$ inches diameter	36	
1927	5 inches diameter	15	Shipping of clams by common carrier prohibited and no clam out of the shell may be possessed unless being prepared for consumption.
1929	5 inches diameter	15	District 18A, area between Le Grande Pier and Santa Maria River mouth, set up as clam sanctuary, no digging at any time.
1931	5 inches diameter	15	Sportfishing license required to take Pismo clams.
1933	5 inches diameter	15	No digging for clams between $\frac{1}{2}$ hour after sundown and $\frac{1}{2}$ hour before sunrise. No clam digging implements in possession on beach during these hours.
1947	5 inches diameter	15	No Pismo clams taken in California can be sold.
1948	5 inches diameter	10	
1949	5 inches diameter	10	District 18A opened to Pismo clam digging and 8 miles of clam bearing beaches closed in San Luis Obispo County (1.5 miles from Morro Rock north; 2.2 miles between the wooden ramps at Oceano and Pismo Beach and 4.3 miles from mouth of Santa Maria River to mouth of Oso Flaco Creek). All undersized clams must be returned to hole from which dug or to deep water.

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A SECOND RECORD OF THE WHALE SHARK, *RHINEODON TYPUS*, IN PANAMA BAY *

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Rhineodon typus, the whale shark, grows to 45 feet (measured) and possibly to 60 feet (estimated), and hence is the largest marine animal next to the large whales. Its broad head covered with small spots, its wide terminal mouth, its three longitudinal ridges on each side, its vertical rows of large whitish or yellowish spots—all are characters, which, taken together, are not found in any other shark. It is found in tropical and warm-temperate waters the world around. In 1935 I published an article on its geographical distribution. In this I listed all the reported records of specimens which I had found in 20 years' search. Among these records was that to which attention will now be called.

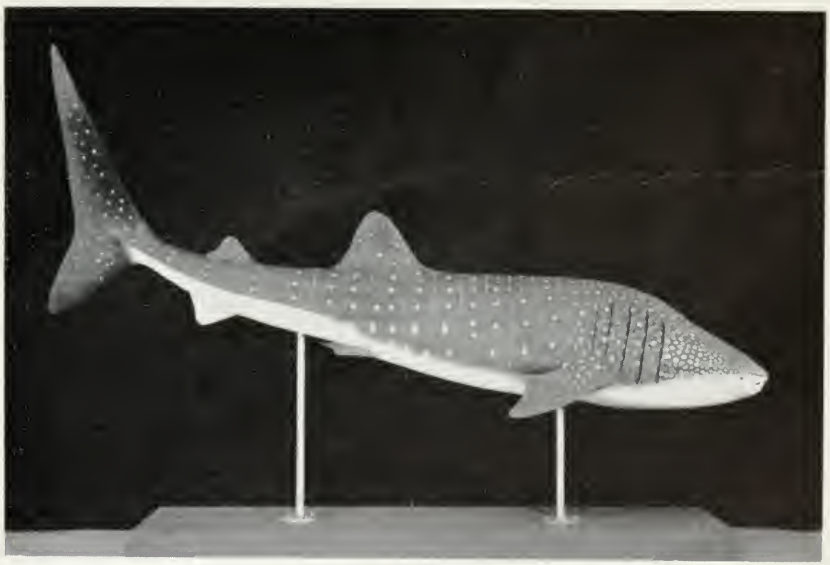

Figure 129. The mounted skin of a whale shark taken at Acapulco, western coast of Mexico, in 1935. It is one of the treasures of the American Museum of Natural History. Before tanning the skin was about 17 feet long.
American Museum of Natural History Photo

THE FIRST PANAMA RECORD—1883

In 1883, the Italian R. N. corvette "Vettor Pisani," G. Chierchia in command, in a voyage around the world, visited Panama Bay. One

* Submitted for publication March, 1950.

day in February the ship was anchored off Taboga Island and the crew were fishing for a shark in a dead calm. Presently, some large sharks were noticed at a considerable distance away. In a short time several native boats, accompanied by two from the ship, set out to investigate the large sharks. One of these was secured after a long, hard fight and was with great difficulty brought alongside the vessel by the nine boats. Because of its "colossal dimensions," the shark could not be hoisted onto the deck, so it was stranded on a nearby sand beach.

Chierchia's description, published in *Nature* in 1884, speaks of the three longitudinal chamferings on each side, the encircling spots, the wide terminal mouth with minute teeth, and the great size. All the characters definitely establish this catch as a whale shark. It was 8.90 meters long between perpendiculars (*c.* 29 ft.) and 6.5 meters in circumference (*c.* 21 ft.). The natives called the great fish "Tintoreva," and the oldest of the villagers said that but once before had they fished for such a spotted shark—and then for a smaller one.

THE SECOND RECORD—1947

This comes as a result of the publication by the present writer in 1949 of a brief note on the third record of a whale shark in the Caribbean Sea—at Puerto La Cruz, Venezuela. This note was seen by Mr. William H. Gaines, Jr., long (since 1932) a resident and airplane pilot in the Panama Canal Zone. Here follows what Mr. Gaines has written about his observations of a whale shark in Panama Bay.

"On June 28, 1947, I was flying a Piper Cub (a light airplane) over the ruins of old Panama, and slightly seaward of the beach. From an altitude of about 2,000 feet, I observed a large marine animal swimming a short distance out from the breaker line. From that altitude I could not identify it, but I thought it was a whale. I closed the throttle and spiraled down to investigate. I made my first pass over the animal at about 50 feet and at about 60 miles per hour. I noticed large white-appearing spots girdling the animal's body from a point just off the head and progressing toward the tail. I still thought it a whale. The second time over, I dropped to about 15 feet and slowed down to about 50 miles per hour. I then noticed the large blunt head and small fins on either side—all similar to those of a whale. But then I also noticed that the tail had vertical flukes like those of a fish instead of the longitudinal ones of a whale. But even then I was hardly sure of what I had seen."

Mr. Gaines then returned to the air field and told his fellow pilots about the strange huge animal he had seen in Panama Bay. Having never observed anything like this in their trips over the bay, the pilots laughed at him and suggested that he was seeing double. Then he persuaded two of them to take their small light planes and follow him. They did so, and he states their observations as follows:

"We buzzed the shark for about 15 minutes, just barely clearing the water, in an attempt to cause some reaction on the part of the great fish, which was as long as one of our small planes, but it completely ignored us. Finally we gave up and returned to the field, wondering what the great fish was."

It should be noted that all through the first and second "buzzings" of the shark by these great objects totally unknown to it, the whale shark was entirely undisturbed and unafraid. This is exactly in keeping with the habits of *Rhincodon*. It is afraid of nothing, since it has no enemies. Those interested in the unafraidness of the whale shark will find everything known of its behavior set out and discussed in the writer's article, "The Whale Shark Unafraid" (1941).

Anxious to identify this huge fish, Mr. Gaines went to the Panama Canal Library and hunted through one natural history book after another, until he finally found a description of a similar shark—a whale shark—seen in the Gulf of California.

At first, no one could be found who had ever seen such a huge fish in Panama Bay. But, in the conversation about this specimen, it presently came out that several young men had seen specimens of this great spotted shark while deep-sea fishing far out in Panama Bay. They, however, had not had the incentive possessed by Mr. Gaines of trying to find out what their great fish was.

One other whale shark has been reported from Panama waters. In 1932, a steamer rammed a whale shark near Burica Point, a promontory in the Pacific on the line between Panama and Costa Rica. This ramming was put on record by the present writer in 1938.

Up to this time, *Rhincodon* has been recorded in the Central Eastern Pacific from the Gulf of California and (especially) from around Cape San Lucas; from Acapulco, Mexico; from Burica Point, N. W. Panama; and in Panama Bay, 1883 and 1947. Off the western coast of South America, it has been recorded at the Galapagos Islands, and as far south (1878) as Callao, Peru. This later record in Panama Bay strengthens our knowledge of the range of distribution of the whale shark in the warm waters of the American Eastern Pacific.

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THE ARTIFICIAL ROOST—A NEW MANAGEMENT TOOL FOR CALIFORNIA QUAIL *

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The three steps in California quail management as set forth by Emlen and Glading (1945) are: "(1) establishing a breeding stock, (2) aiding and protecting this stock during its development, and (3) harvesting the surplus." The second step consists of providing quail habitat and protection against enemies and overshooting.

Quail habitat, or the living space for quail, is compounded of food, cover, and water in the proper proportion and distribution. Valley quail have a special cover requirement in that they roost in densely foliaged trees or in tall shrubs. In some areas lack of adequate roosts is believed to be the reason for low density populations.

A new tool in the management of quail cover has been devised by Ian McMillan, a rancher in eastern San Luis Obispo County. McMillan (1947) has described how 12 pairs of quail were released on his ranch in 1946 in an area which was previously occupied by quail but where they no longer occurred. Food, cover, and water were made available and the birds increased to 49 in January, 1947, 153 in February, 1948, 192 in January 1949, and 435 in November, 1949.

These birds roosted in two olive trees in the ranch yard which provided the only suitable roosting cover in their territory. The trees which were adequate for the smaller number did not provide sufficient cover for the 435 birds. When there were 435 quail trying to roost in these two trees every limb was covered and any owl that landed in the trees was almost sure of landing on a bird and flushing the remainder from their roost. Thus the owl would not only take one of the birds, he would seriously disrupt the rest of the covey.

In order to provide additional roosting cover to protect the quail from nocturnal predators, Mr. McMillan constructed two artificial roosts. These roosts were immediately taken to by the birds and provided very adequate protection. As soon as the roosts were constructed a majority of the birds roosted in their heavy cover in preference to the olive trees.

The Division of Fish and Game, through Federal Aid Projects California 26-D and California 33-R, has constructed roosts of the McMillan type in areas where roosting cover is the limiting factor. Although figures are not yet available as to the effect of these roosts on quail populations, it seems safe to conclude, from the heavy use they receive where roosting cover is a limiting factor, that they will fill in a gap in the habitat and increase the quail population.

* Federal Aid in Wildlife Restoration Act, California 33-R. Submitted for publication March, 1950.

In California, as in much of the southwest, there are many square miles of potential quail range that have more than ample feed and escape cover. Water and roosting cover are scarce or lacking over much of this area. The water requirement is being met by installation of the "gallinaceous guzzler" by Federal Aid Project California 26-D. The McMillan roost promises to make much of the balance of this arid, brushy country available to quail by supplying the other environmental need—roosting cover.

The roosts currently being constructed by the Division of Fish and Game are 6½ feet high by 8 feet by 16 feet (Figure 130). They are con-

FIGURE 130. McMillan Roost constructed by the Division of Fish and Game. *Photo by E. S. James.*

structed from old two-inch pipe which is obtainable at little or no cost. The supports consist of four 8-foot lengths of pipe. The ends of these pipes are heated, flattened, and bent at right angles. Then a ½-inch hole is drilled in this flattened portion. The other end of the pipe is set 1½ feet deep in concrete in a post hole. The framework consists of two 8-foot lengths and two 16-foot lengths. Both ends of these pipes are flattened and one-half inch holes drilled in the flattened portion. The framework is fastened together and attached to the supports by three-eighths inch bolts which pass through these holes (Figure 131).

FIGURE 131. Corner of framework showing how pipes are fastened together.

After the framework is erected, hog wire fencing, or other similar material is fastened to the framework and then brush is piled on top of the wire-covered framework (Figure 132). The brush should consist of

FIGURE 132. Framework is covered with hog wire and brush piled on top.
Photo by E. S. James.

crooked limbs of juniper, oak, or some similar material, not straight-limbed brush which will pack down. It is important that sufficient brush is used to provide good, dense cover and protection for the birds. It is believed advisable to construct these roosts in groups of two about 50 yards apart so that if the birds are flushed from one they can fly to the other. In arid range country, it is felt that ideal placement of these devices involves putting them at least 200 yards and not more than one-half mile from available water. Present indications are that canyon bottoms provide the best sites.

The artificial roosts are actually more predator-proof than natural roosts as the heavy brush protects the quail from aerial predators and the iron supports protect them from ground predators.

In addition to this type of artificial roost, the Division of Fish and Game is improving roosts in deciduous blue-oak areas of the Sierra foothills. In these areas instead of constructing an iron framework, a fair-sized blue oak tree (*Quercus douglasii*) is selected, three of the limbs are cut off where they fork, and limbs are piled in this fork to provide dense roosting cover. If it is felt ground predators are a serious problem, a strip of tin is wrapped around the trunk of the tree.

In addition to providing roosting cover these roosts are used by quail and other birds during the day and they also provide shade for livestock during the hot summer and fall months.

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RECENT RECORDS OF THE WOLVERINE *(GULO LUSCUS LUTEUS)* IN CALIFORNIA *

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Little is known of the status of the wolverine in California beyond the fact that it is rare. The only estimate of numbers dates back to 1937 when Grinnell, Dixon and Linsdale (1937) judged the population of the State to be 15 pairs, all occurring in the southern Sierra Nevada between the Tahoe area and Walker Pass. Since that time few additional accounts have been published.

While engaged in a field study of the Sierra Nevada mountain sheep in 1948, several heretofore unrecorded observations of wolverines became evident. Sixteen unpublished records which seem reliable are summarized in chronological order in Table 1. Additional details regarding some of these observations are offered in the following paragraphs.

In the winter of 1929 Orland Bartholomew followed one wolverine for five days in the high country of Kings Canyon National Park. He first came across the tracks near the summit of Glenn Pass. As he followed the trail down toward Rae Lakes, 1,500 feet below, he noticed that the animal had closely followed each twist and turn of the trail, though in many places shortcuts would have saved time and distance. Since the trail was completely obliterated by snow, the route must have been familiar to the wolverine under summer conditions. On steep and slippery descents the animal had slid down backward, scratching long marks with its claws. The trail continued past Rae Lakes down the South Fork to Woods Creek, making a total trip of approximately 12 miles. On two occasions the wolverine had passed within a few yards of porcupines without molesting them. Three days later, on February 15th, Bartholomew sighted a wolverine near Woods Creek (presumably the same individual) and watched it pick its way around a slope and climb a pine tree. He stated that the size of the track was misleading, as the animal proved to be considerably smaller than he had anticipated. A photograph of the track is reproduced in Figure 133.

* Submitted for publication January, 1950.

TABLE 1

Reports of Wolverines or Their Sign Observed in the Southern Sierra Nevada From 1927 to 1948

Authority	Locality	Date	Observation
Sam Griggs, Independence	Between Colby Mdws. and Evolution Lake, Kings Canyon Nat'l Park.	Winter, 1927	Wolverine followed Griggs for eight days. Was seen several times.
Orland Bartholomew, Auberry	Between Glenn Pass and Woods Cr., Kings Canyon Nat'l Park.	Feb. 11-15, 1929	Tracks of one wolverine followed by Bartholomew for five successive days. Wolverine seen.
Orland Bartholomew, Auberry	Silver Pass, Fresno Co.	Mar. 21, 1929	Tracks of two wolverines seen.
Tom Dahl, trapper	Bourland Mdws., Tuolumne Co.	Early 1930's	Wolverine tracks seen.
E. L. Shellenbarger, U. S. Forest Service	Tyndall Cr., Sequoia Nat'l Park	Early 1930's	Six wolverines seen together by Mr. H. A. Simpson (reported to Shellenbarger).
E. L. Shellenbarger, U. S. Forest Service	Above Tunnel Mdws., Tulare Co.	1931	One wolverine seen.
E. L. Shellenbarger, U. S. Forest Service	Near Tunnel Mdws., Tulare Co.	1933 or 1934	Cattlemen reported having seen two wolverines together on different occasions.
Norman Clyde, guide	Near Paradise Valley, Kings Canyon Nat'l Park.	About 1933	One wolverine seen.
Oliver Kehrlein, Sierra Club	White Mt. Pk., Inyo Co.	Summer 1937	One wolverine seen.
E. L. Shellenbarger, U. S. Forest Service	Rocky Basin, Tulare Co.	About 1938	One wolverine seen.
Clarence Fry, U. S. Park Service (ret.)	Mosquito Lake, Sequoia Nat'l Park	Summer 1940	One wolverine seen by a fisherman (reported to Fry).
Norman Clyde, guide	N. Fork Big Pine Cr., Inyo Co.	Winter 1941 or 1942	Sign of one wolverine seen.
Jack Collins, packer	Rae Lakes, Kings Canyon Nat'l Park	Summer 1946	One wolverine seen.
Clarence Fry, U. S. Park Service (ret.)	Granite Pass, Kings Canyon Nat'l Park	Summer 1947	One wolverine seen (reported to Fry).
Bill Garner, packer	Clover Leaf Lake, Mono Co.	Summer 1947	Tracks of one wolverine seen (reported to Garner).
Fred L. Jones	½ mi. E. of Dragon Lake, Kings Canyon Nat'l Park	Summer 1948	Tracks of one wolverine seen.

FIGURE 133. Wolverine tracks in snow below Glenn Pass, Kings Canyon National Park, February 11, 1929. *Photo courtesy of Orland Bartholomew.*

The 1937 sight record of a wolverine in the White Mountains by Oliver Kehrlein is noteworthy because no previous record exists from that area. Though lacking confirmatory notes or other evidence, Kehrlein recalls that at the time he was certain that the animal observed was a wolverine.

The wolverine seen at Mosquito Lake and reported to Clarence Fry was surprised by a fisherman as it was eating trout from his creel. Officers of Sequoia National Park examined the tracks after the animal had left and confirmed the identification.

The tracks that the author observed above Dragon Lake were in the gravelly sand that is so characteristic of alpine regions in the Sierra Nevada. Though they were not clear enough to distinguish pad impressions, their large, rounded form and short spacing strongly suggested wolverine. In gross appearance the trail was very similar to that shown in the photograph by Bartholomew.

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GROUND SQUIRRELS AND HORNED LARKS AS PREDATORS UPON GRUNION EGGS *

By Andrew C. Olson, Jr.
San Diego State College

Thompson (1919), in a discussion of the enemies of the eggs of the beach-spawning grunion (*Leuresthes tenuis*), lists the histerid beetle *Saprinus sulcifrons* Lec. as the only serious enemy of the eggs and suggests that its attacks on the eggs may be the result of straying from the normal habitat. Clark (1925 and 1938) lists no other serious enemies. Walker (1949, p. 65) reports marbled godwits and hudsonian curlews feeding on grunion eggs. I wish to report a series of field and laboratory studies which establish additional enemies of grunion eggs and extend the spawning area beyond that previously reported. Specific identification of the histerid beetle was made by Mr. Gordon Marsh of the San Diego Museum of Natural History.

The area of study is on the San Diego Bay side of the Coronado Strand, Coronado, San Diego County, California (Figure 134). Observations reported here refer primarily to the rather narrow north-shore beach of a man-made area three miles south of the Hotel del Coronado. This mile-long area was built up of dredged mud, sand, rocks and shells in 1941, and is now used for naval training maneuvers. It averages one-fourth mile in width and is 12 to 14 feet above mean lower low water in height. The above-mentioned beach is backed by a rather abrupt two- to six-foot bank containing numerous ground squirrel (*Citellus beecheyi*) burrows (Figure 135).

On July 3 and 4, 1949, I observed and photographed "diggings" which were attributed to ground squirrels (Figures 135 and 136). The diggings first attracted my attention by their being along uniform contours rather than scattered at random over the beach. They were surrounded by squirrel tracks and presented the appearance of having been squirrel-made. Two contained fecal pellets later determined to be from squirrels. The depth of the diggings varied from $3\frac{3}{4}$ inches to mere scratches of the surface and dried grunion eggs were visible on the surface of the sand in many of them. By digging at the same contour level I was able to uncover numerous pods of eggs but digging above and below the level yielded none. Thus, their distribution corresponded with the distribution of egg pods as shown by Thompson (1919, Chart 2). There were two conspicuous levels at which these diggings were observed. The most abundant ones were below the highest tide mark while others were at the base of a two- to five-inch wave-cut ledge apparently cut at the highest reach of a high tide (Figure 135, A).

On July 3d and 4th, observations of the squirrels themselves was precluded by activities of other persons who kept the squirrels under

* Submitted for publication January 1950.

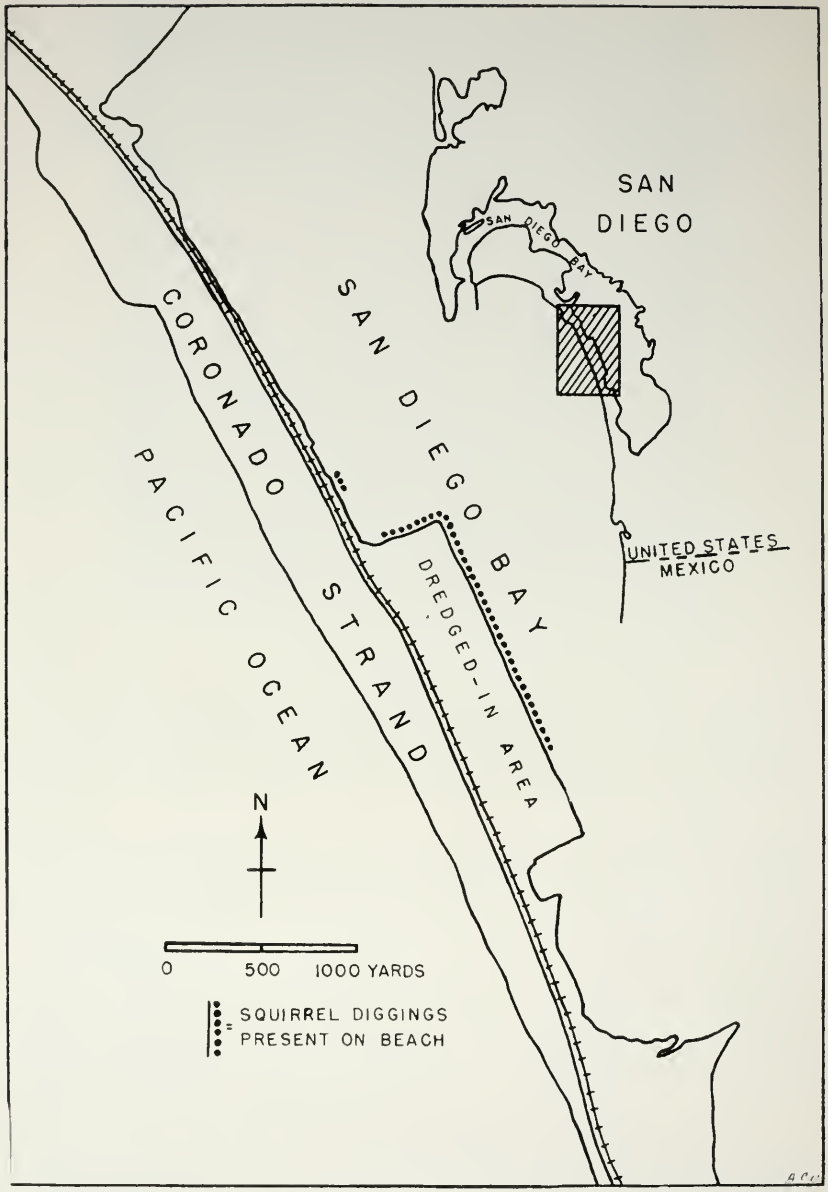

FIGURE 134. Orientation map of the beach area on which squirrel diggings were found.

FIGURE 135. North-shore beach of dredged-in area showing bank with squirrel burrows indicated by arrows and the squirrel diggings located at two levels, indicated by A and B, on the beach.

cover; however, a visit to the area on the morning of July 16th was highly successful in that the squirrels were active and relatively undisturbed. Three were observed in a seven-foot section of the beach. One of these was collected and the viscera preserved. Later laboratory examination indicated the following in the stomach: 400+ grunion eggs, numerous seeds, *Oenothera bistorta* petals and sand.

Dried squirrel droppings, taken from diggings and soaked in water before being teased apart, contained some entire grunion eggs, some egg membranes, sand and miscellaneous material.

Also on July 16th, horned larks (*Otocoris alpestris*) were observed to favor for their foraging the areas of loose sand around the squirrel diggings and they were seen to flick sand from side to side with their bills. An immature male was collected, and the gizzard was found to contain 17 entire grunion eggs, 22+ crushed eggs, eight small seeds, one entire beetle (*Saprinus serrulatus* Lec.), numerous parts of the same species of beetle and sand.

The above observations are interesting in that two terrestrial vertebrate species are shown to be taking advantage of a seasonal phenomenon on a man-made beach which has been extant only since 1941. The grunion spawn from February until September as extreme limits, and from March to July as usual limits, on the high spring tides which accompany the full moon and the new moon, and only at night (Walker, 1947). Thus, the egg deposits would be expected to be on a given level for one night's spawning. The eggs themselves are deposited in pods two or three inches below the surface and are often further covered to a greater depth by subsequent tides. Each pod measures about five-eighths inch in diameter

FIGURE 136. Squirrel diggings in beach sand. Size indicated by the 6 inch ruler.

and contains an average of over 2,000 salmon-pink eggs about one-sixteenth inch in diameter. Under ideal conditions the eggs are ready to hatch in nine days and will be uncovered by the next series of high tides. During the period between series of high tides the squirrels and larks are able to uncover and feed upon the eggs.

The fact that the squirrels initiate the diggings on the beach and feed upon the eggs thus uncovered places them in the roll of primary predators. As the eggs recovered in the gizzard of the horned lark were not dried out, it must be that the larks in turn uncover eggs where the squirrels have already loosened the sand. No observations were made which would indicate that the horned larks initiated any of the diggings and no evidence of diggings of any kind was found where squirrels were absent even though horned larks and grunion eggs were to be found. The evidence tends to place the larks as secondary predators as they seem to take advantage of the initial diggings of the squirrels who are not so well adapted to pick out the individual small eggs from the sand as are the larks. It is of interest also to note that the horned larks in preying upon histerid beetles are in turn preying upon one of the probable predators of the grunion eggs.

In collecting pods of grunion eggs to be returned for observation in the laboratory, the histerid beetle (*Saprinus serrulatus*), an oxyuroid nematode and a small annelid worm (Family Enchytraeidae) were conspicuous by their presence in the sand immediately surrounding the eggs. Similar collections of sand taken from areas of the beach away from the egg pods yielded very few of the histerids and annelids, and none of the nematodes. In the laboratory no damage to the eggs by the worms was noted and the worms indicated no positive tropisms toward the eggs. No tests were conducted to check for damage to the eggs by the beetles. It

may be supposed that they would have the same habits as the species listed by Thompson, particularly with the local species being found in such intimate association with the egg pods.

In beach areas where ground squirrels are present the finding of diggings as described here gives a good clue as to where and when grunion are spawning. The area described is much farther within San Diego Bay than any where grunion spawning has been previously reported and it was located as the result of the squirrel activity. In addition to the diggings along the north-shore beach of the dredged-in area, similar activity was observed for three-fourths mile south along its eastern border and one-fourth mile to the north where a rubble area afforded suitable habitat for squirrels (Figure 134).

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NOTES

CALIFORNIA ANTELOPE REPRODUCTIVE POTENTIALS

Productivity of the pronghorn antelope herds is normally measured by field observations on the kid crop during the kidding season. Einarsen (1948) states that "Observations and available records indicate this (potential birth rate) to vary from year to year between one and two kids." Further observations cited by this author (*op. cit.*, Table 9, p. 126) indicate that single births predominate over twin births.

Information gathered as a result of recent antelope trapping and transplanting operations during December 1949 and January 1950 shows that the reproductive potential of antelope in Lassen County, California, may be considerably higher than field surveys would indicate. During the course of this trapping operation a combination of handling difficulties coupled with extremely adverse weather, resulted in the loss of 27 antelope. Of this total, one was an adult male, two were male fawns, two were female fawns, two were female yearlings (19-20 months old) and 20 were adult females. Stomach contents of all these antelope were saved for examination and all of the females were autopsied and examined for embryos. Data gathered as a result of these examinations bring out some interesting facts relative to the reproductive potential of this herd of pronghorn antelope.

PRODUCTIVITY

Findings relative to the breeding potential of California antelope are summarized in Table 1. Although the number of animals examined is small, indications are that fawns and yearling females may not be a

TABLE 1

Pregnancy Data—Lassen County, California, Antelope

Age	Number females examined	Number females pregnant	Percentage pregnant
Fawns (7 mo.)	2	0	0.0
Yearlings (19-20 mo.)	2	0	0.0
Adults (all ages)	20	18	90.0

significant factor in herd productivity. Adult females on the other hand show a high incidence of pregnancy.

Considering further only those adult females which were found to be pregnant it was observed that their reproductive potential was very high. These data are summarized in Table 2. It will be noted from examination of Table 2 that only one single embryo was found as compared with 17 sets of twin embryos. No occurrence of triplets was recorded.

TABLE 2

Occurrence of Embryos in Pregnant Female Antelope

Number females pregnant	18
Number single embryos	1
Number twin embryos	17
Total embryos	35
Embryos per pregnant antelope	1.94

EMBRYO SEX RATIO

The age of all embryos at the time of examination was sufficient to permit accurate sexing. Data relative to the occurrence of embryos by sex is summarized in Table 3.

TABLE 3

Occurrence of Embryos by Sex

Embryos	Number of occurrences	Percentage	Total embryos	
			Female	Male
1 female	1	5.5	1	
1 male, 1 female	14	77.9	14	14
2 females	2	11.1	4	
2 males	1	5.5		2
Totals	18	100.0	19	16

These data indicate the sex ratio of males to females at birth would be 84:100. The number of sets of twins of identical sex (3) compared to the number of sets of twins of opposite sex (14) seems disproportionately low when considered in the light of productivity data gathered on deer (Chattin, 1948; Robinette and Olsen, 1944). This is probably due to the small size of the sample and the ratio might be expected to approach equality when additional information is secured.

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John E. Chattin and Robert Lassen, Bureau of Game Conservation, California Division of Fish and Game, March, 1950.

NOTES ON TWO SPECIES OF SHARKS FROM BAJA CALIFORNIA

In the fall of 1949, the Division of Fish and Game's new research vessel "Yellowfin" made its initial cruise along the Pacific Coast of Baja California. During the trip, which was carried out in conjunction with the Division's mackerel and sardine investigations, a number of sharks were collected, including representatives of two species which are of more than passing interest.

What appears to be the seventh recorded specimen of *Carcharhinus velox* Gilbert (Figures 137 and 138) was obtained at Outer Gorda Bank, just inside the Gulf of California. The species is distinguished from other eastern Pacific members of the genus by the extremely enlongate snout and by the long, relatively closely placed nostrils. This shark was entangled in a $2\frac{1}{2}''$ stretched mesh gill net which formed part of a string drifted during the night of October 6-7, 1949. Data for this station are: Location at start of set, Lat. 23° 00.5′ N., Long. 109° 28′ W.; drift 2 miles northeast in 12 hours; water temperature 84° F.; depth of water, 34 fathoms at start of set, 105 fathoms at end of drift; fishing depth of nets 8 to 13 fathoms; other fish caught, 12 scads, *Decapterus* sp., 4 green jacks, *Caranx caballus*.

According to Beebe and Tee-Van (1941), three of the previously recorded specimens including the type were taken in Panama Bay, one was from Costa Rica, one from the Gulf of California and one from San Lucas Bay. The largest of these measured 1,200 mm. (47 inches), somewhat smaller than the Gorda Bank fish which was 1,360 mm. ($53\frac{1}{2}$ inches) long.

FIGURE 137. *Carcharhinus velox*, total length 1360 mm, from Gorda Bank, Baja California. *Photograph by Vernon M. Haden, San Pedro.*

FIGURE 138. *Carcharhinus velox*. Lower surface of head of specimen shown in Figure 137. *Photograph by Vernon M. Haden, San Pedro.*

Measurements in millimeters made with dividers from point to point (not as projections) are as follows:

Total length, 1,360; predorsal length, 460; prepectoral length, 345; prepelvic length, 691; preanal length, 863; snout to second dorsal, 871. Distance between dorsal origins, 429; between insertions of paired fins, 368; from pelvic insertion to anal origin, 183; from second dorsal origin to upper caudal pit, 138; from tip of second dorsal to upper caudal pit, 46; from anal origin to lower caudal pit, 137. Greatest depth, 204 (this measurement is of little meaning as the shark's belly was noticeably distended); least depth, 48; greatest width, 162; width opposite upper caudal pit, 38. Head length (to nearest point of first gill slit), 280; head width (between first gill slits), 140. Interorbital width (fleshy), 115; suborbital width, 108. Orbit diameter: Horizontal, 21; vertical, 18. Orbit to nostril, 62; to junction of lip furrows, 53. Snout, preocular length, 137; preoral length, 134; tip of snout to outer edge of nostril, 76. Nostril length, 24; interrarial width: Least, 29; greatest, 70; inner edge of nostril to front of mouth, 60. Width of mouth between ends of gape, 93; front of mouth to line joining ends of gape, 47; upper labial furrow, 7; lower labial furrow, 5. Distance between first and fifth gill openings, 70. Length of gill openings: 1st, 33; 2d, 40; 3d, 45; 4th, 47; 5th, 38. First dorsal fin: Base, 127; origin to upper tip, 168; lower posterior edge, 52; vertical height, 126. Second dorsal fin: Base, 45; origin to upper tip, 52; lower posterior edge, 54; vertical height, 38. Anal fin: Base, 50; origin to upper tip, 71; lower posterior edge, 54. Pectoral fin: Base, 79; origin to lower tip, 220; upper posterior edge, 85; outer margin, 175. Pelvic fin: Base, 66; origin to lower tip, 79; upper posterior edge, 48. Caudal fin: Upper pit to tip of upper lobe, 362; lower pit to tip of lower lobe, 153; upper pit to apex of notch in upper lobe, 278; upper pit to nearest point of posterior margin, 114. These measurements were made by John E. Fitch and the writer after the specimen had been frozen and thawed. It has been deposited at the University of California at Los Angeles.

About a dozen specimens 15 to 20 inches in length of the sharpnose shark, *Scoliodon longurio* (Jordan and Gilbert) were caught on hook and line in the evening of October 2, 1949, at Abreojos Anchorage (Lat. 26° 42′ N., Long. 113° 33′ W.). The depth of the water was six fathoms and its temperature 71° F. On October 8, 1949, three more specimens of about the same size were taken at Santa Margarita Island,

Magdalena Bay (Lat. 24° 31.5′ N.; Long. 111° 54′ W.). These were obtained on hook and line in 10 fathoms of water.

This shark was unknown on the Pacific Coast north of Cape San Lucas until Hubbs and McHugh (1950) recorded one specimen taken off San Diego and five from the southern half of Baja California, all collected in the period August-October, 1948. They regarded these captures in such a limited time as a coincidence rather than as an indication of a northward dispersal, pointing out the lack of intensive collecting along the Pacific Coast of the peninsula. Apparently the species is at least locally abundant for some distance north of the cape.

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Phil M. Roedel, Bureau of Marine Fisheries, California Division of Fish and Game, March, 1950.

NOTES ON THE OCCURRENCE OF THE BIGMOUTH BUFFALO IN SOUTHERN CALIFORNIA

The bigmouth buffalo, *Megastomatobus cyprinella* (Valenciennes), although a common fish in many parts of the East and Middle West, has not previously been reported in the literature as being present in California. This species is now known to occur in several reservoirs of the Los Angeles Aqueduct system. Positive identification was made by Dr. Carl L. Hubbs from two specimens recently obtained from Chatsworth Reservoir near Los Angeles. Whether the closely related smallmouth buffalo, *Ictiobus bubalus*, is also present cannot be determined without further investigation.

The bigmouth buffalo is a member of the family Catostomidae, but in appearance more nearly resembles a carp than a sucker. Such characteristics as the robust body with a rather high arched back and a terminal but inferior mouth aid in its recognition. The few elongated anterior dorsal fin rays are also quite distinctive. Adult specimens in these reservoirs are reported commonly to attain a weight of six or eight pounds.

How and when it was introduced into the area, the writer has been unable to determine. It may have been introduced from several sources, since commercial seiners travel widely throughout nearby states to obtain buffalo for sale in the fresh fish markets of the larger cities, where they bring a much higher price than do carp. It is not uncommon for Los Angeles fish markets to receive shipments of buffalo from Arizona and Utah. Although known facts to support the case are lacking, it is possible that some commercial operator desirous of providing a more readily available local supply carried out the introduction. If this is true, one might speculate that the most probable source of the introduction of this fish was the Roosevelt Dam impoundment in Arizona, since several local commercial seiners have operated there.

Approximately seven or eight years ago the first bigmouth buffalo were noted in the aqueduct system in upper and lower San Fernando Reservoir, located approximately 20 miles northwest of Los Angeles. They have subsequently been distributed through natural movement and direct transportation until at present they are reportedly found in 11 reservoirs of the aqueduct system namely: Upper and lower Haiwee, Fairmount, Dry Canyon, Bouquet, Chatsworth, upper and lower San Fernando, Rowena, Silver Lake and Ivanhoe Reservoirs. With the exception of the Haiwee Reservoirs, which are in Inyo County, all of these reservoirs lie within Los Angeles County.

Little is known concerning the relationship of the bigmouth buffalo to the general ecological picture in these reservoirs. Initial food studies by water sanitation engineers of the Los Angeles Department of Water and Power indicate a high percentage of crustaceans in its diet. If its value in controlling crustaceans which may be detrimental to domestic water supplies can be demonstrated by additional study, it is their desire to increase its numbers in all of these reservoirs. The writer believes that it is important to confine the buffalo to this water system until further observations can be made regarding its relationships to other fishes.—*Willis A. Evans, Bureau of Fish Conservation, California Division of Fish and Game, January, 1950.*

RETIREMENT OF BENJAMIN R. SAUNDERS

Mr. Benjamin R. Saunders, Senior Accountant, retired on April 30, 1950, having reached the age of seventy. He had been in the state service for over 30 years. Although Mr. Saunders was on the pay roll of the Department of Finance, he worked under a loan agreement for the Division of Fish and Game.

His gracious personality made him a treasured friend of everyone who had the privilege of associating with him. No finer testimonial could be paid to the esteem at which he was held by his associates in the state service and by members of the fishing industry than was exhibited by the astounding response to invitations to a banquet given in his honor in San Francisco on April 13, 1950, at which friends from the length and breadth of the State came to wish him a full and happy retirement.

During his long assignment with the Division of Fish and Game, Mr. Saunders audited the books of wholesale fish dealers and processors to ensure compliance with fish and game laws and regulations. While carrying out his duties, he worked very closely with members of the Bureaus of Patrol and Law Enforcement and Marine Fisheries. His diplomacy, outstanding character, and friendliness won him the enviable reputation of being the outstanding public relations agent of the Division's staff.—*Richard S. Croker, Chief, Bureau of Marine Fisheries, California Division of Fish and Game, May, 1950.*

IN MEMORIAM

RUDOLPH GERHARDT

Warden Rudolph Gerhardt passed away at the Gridley Hospital on March 17, 1950. He entered the hospital about a week prior to his death.

Rudy Gerhardt joined the division in 1937 as an assistant warden, and worked in several of the bureaus until 1943, when he became a permanent warden with the Bureau of Patrol. Warden Gerhardt's assignment was the waterfowl and pheasant areas in the vicinity of Gridley. He was highly regarded for his proficiency in handling a difficult patrol area.

He leaves a wife, Shirley Gerhardt, to whom the department extends sincere sympathy.—*L. F. Chappell, Chief of Patrol, California Division of Fish and Game, March, 1950.*

FRED W. HECKER

We regret to report the death of Captain Fred W. Hecker of San Luis Obispo, which occurred January 20, 1950. Captain Hecker, in company with Warden Fullerton, and a member of the Highway Patrol, was patroling the beaches between Avila and Morro. He disappeared from sight of his companions, and a short time later his body was observed in the water of the ocean some short distance from the rocks. Every effort was made to recover the body, to no avail.

Captain Hecker was appointed deputy fish and game warden in April, 1931. He was detailed for work in the Big Pine area in Inyo County, and later to the Coachella Valley in Riverside County. On March 10, 1932, he was stationed at San Luis Obispo County and continued in that county until the time of his death. Fred Hecker was appointed captain of the Bureau of Patrol in the fall of 1942, and served in this capacity until his death.

Captain Hecker had many friends, and was a great favorite with other members of the bureau. He leaves a wife and daughter, to whom we wish to express our sincere sympathy.—*L. F. Chappell, Chief of Patrol, California Division of Fish and Game, March 1950.*

EARL I. HISCOX

Earl I. Hiscox was appointed a deputy with the Bureau of Patrol in July 1928, and passed away at his home in Nevada City on November 3, 1949, after a short illness.

Most of his career with the division was spent in Nevada County, where he had a host of friends. He was regarded very highly by the department as an officer and employee.

Our sincere sympathy is extended to his wife and family.—*L. F. Chappell, Chief of Patrol, California Division of Fish and Game, March, 1950.*

HENRY OCKER

Henry Ocker joined the Division of Fish and Game as an assistant fish and game warden on August 5, 1937. He worked for both the Bureaus of Fish and Game Conservation until 1940, when he became a warden in the Bureau of Patrol. His assignments were at King City, Monterey County, Julian, San Diego County, and since December 15, 1949, Markleeville, Alpine County.

He recently entered the Veteran's Hospital at Reno, Nevada, to undergo an operation, and passed away on February 26, 1950. He was buried at San Diego.

Henry Ocker will be missed by his friends and associates, and our sincere sympathy goes to Mrs. Ocker and family.—*L. F. Chappell, Chief of Patrol, California Division of Fish and Game, March, 1950.*

REVIEW

An Illustrated Key to the Lizards, Snakes and Turtles of the West. Vol. 2. Naturegraph Pocket Keys. By Jay M. Savage, Naturegraph Company, Los Altos, California, 1949, 33 pp., $0.50.

This is a convenient pocket size booklet for identifying reptiles in the field. Its scope is confined to the United States and Canada west of the Rocky Mountains. The key is well illustrated and should be easy to use after a little study. The ranges of the various species are delineated on small maps by shading. This should be a very handy aid to all naturalists, field men and others interested in the outdoors who wish to identify the various reptiles they encounter in the field. There are no descriptions of any of the species, that being left to other books; this is nothing but a key for identification. A list of references is included in the back for those who wish to secure further information on any species.—*Herbert L. Hagen, University of California.*

ERRATUM

The Life History of the Greaser Blackfish *(Orthodon microlepidotus)* of Clear Lake, Lake County, California, vol. 36, no. 2.

On page 124, line 14, read *Dorosoma cepedianum* for *Dorosoma smathi.*

REPORTS

FISH CASES

January, February, March 1950

Offense	Number arrests	Fines imposed	Jail sentences days
Abalone: Closed season; no license, overlimit; undersize; out of shell; failure to show license on demand	169	$3,725 50	15
Angling: Fishing within 150 feet of the lower side of a dam; no license; failure to display angling license; possession of spear within 300 feet of a stream; possession of a gaff within 300 feet of a stream; using an angling license not issued to her; making a false statement when procuring an angling license; angling with more than one rod; angling in closed area; closed season; night fishing; seining; back dating an angling license; operating a set line; transferring his angling license	271	3,970 50	20
Black bass: No angling license; closed season; using more than 1 pole; using set lines	1	260 00	
Striped bass: Using 2 lines; overlimit; undersize; night fishing; possession for sale of striped bass; possession transportation for sale; no license	45	1,395 00	
Carp: No wholesale license	1	100 00	
Catfish: No license; undersize; failure to give buyer's receipt; using 3 poles; using 2 poles	9	165 00	
Big Neck clams: Overlimit; no license	12	345 00	
Cockle clams: Overlimit; no license; failure to show license on demand	26	565 00	
Gaper clams: Overlimit	3	80 00	
Pismo clams: Undersize; making a false statement to secure a license; late digging; no license; failure to display license; overlimit; possession clam digging forks and digging in a refuge	101	2,110 00	130
Commercial: No license; no party boat records; use of round haul net in closed area District 19A; failure to deliver records; operating a round haul net in District 20; failure to register a commercial fishing boat; assisting in operation of a gill net	192	1,560 00	
Crabs: Closed season; undersize	1	75 00	
Crappie: Closed season	2	50 00	
Lobsters: Undersize; failure to show angling license on demand; failure to show lobsters on demand of warden; use of lobster traps in closed District 21; wilfully disturbing lobster traps being legally fished by another fisherman	11	328 00	39
Octopus: No license	1	25 00	
Pike: No license	1	10 00	
Pollution: Permitting petroleum oil to enter State's waters; by use of bluestone and black leaf 40; by use of copper sulphate; by use of clorox; placing fish refuse in the waters of Fish Harbor; by use of chloroform	21	1,715 00	
Salmon: No license; using firearms; spearing; closed stream; possession of a gaff within 300 feet of a stream; closed season; angling within 150 feet of lower dam; illegal possession	13	210 00	
Sardines: Canning sardines taken for bait	1	100 00	
Sturgeon: Possession of a sturgeon; possession of sturgeon roe	3	225 00	
Sunfish: No license; closed season	3	60 00	
Trout: Closed season; taking trout in District 103.6; possession of a gaff hook within 300 feet of a stream; chumming for trout; no license; use of artificial light; overlimit	19	690 00	50
Totals	909	$21,094 00	251
Court forfeitures: (Confiscated fish)		$777 58	

GAME CASES

January, February, March 1950

Offense	Number arrests	Fines imposed	Jail sentences (days)
Bear: Taking bear with trap	1		
Beaver: Taking beaver for profit without a license; trapping beaver in closed area	3	400 00	
Deer: Doe; closed season; using a .22 caliber rifle; possession illegally taken deer; a California resident possessing deer on a Montana resident license; no transport permit; no evidence of sex; allowing dogs to run deer in closed season; possession of forked-horn deer in District 1¾; spotlighting; taking a spike buck; transporting illegal deer into California; no valid hunting license; night hunting	58	5,948 00	975
Deer meat: Possessing deer meat in closed season; a California resident possessing deer meat on a Colorado resident license; no transport permit; no evidence of sex; possessing parts of illegally taken deer; possessing parts of a spike buck; possession of deer meat and gun in refuge 4f; failure to show deer meat upon demand; possession of parts of a doe; illegal possession of deer meat; possession of unstamped deer meat; purchase of deer meat	38	2,900 00	36
Doves: Illegal import of doves; closed season; overlimit	13	395 00	
Ducks: Late shooting; shooting from a motorboat; no license; out of season; overlimit; unplugged shot gun; driving ducks with an airplane; having in possession ducks taken after lawful shooting time; hunting on a refuge; illegal hunting license; failure to declare game; early shooting; purchase of ducks	144	6,210 00	
Elk: A California resident possessing elk on a Wyoming resident license; no transport permit; no evidence of sex	1	100 00	
Geese: Overlimit; shooting from a motorboat; unplugged gun; late shooting; closed season; using a .22 caliber rifle; no stamp; possession of firearm and geese on refuge; no license; stealing game; night hunting	45	1,715 00	
Hunting: Shooting from a motorboat; late shooting; possession of firearms in a game refuge; no license; hunting on posted land; hunting in closed zone in a cooperative hunting area; using unplugged shot gun; shooting game from an automobile; hunting trespass on G.M.A.; illegal import of game; trespassing on shooting grounds; early shooting; failure to show license on demand; possession of arm band off cooperative hunting area; hunting on restricted cooperative area; trespassing on restricted cooperative area; spotlighting	155	3,994 70	
Migratory waterfowl: Taking a fully protected migratory waterfowl bird; using a .22 caliber rifle; late shooting; no license; early shooting; shooting from a power boat; closed season; unplugged gun	52	1,575 00	
Nongame birds: Taking nongame birds; no license; making a false statement to get a license	4	100 00	
Pheasants: Hen pheasant; spotlighting; out of season; failure to tag pheasant; illegal import of pheasants; no evidence of sex; no license; overlimit; unplugged gun; taking pheasant in cooperative area, no permit; using a .22 caliber rifle; early hunting; trespassing on cooperative pheasant hunting area; hunting on pheasant cooperative restricted area; shooting from motor vehicle; taking and possessing a cock pheasant on refuge	53	3,100 00	100
Quail: Closed season; using a .22 caliber rifle; holding valley quail without a permit; trespassing on a restricted cooperative area	12	550 00	
Rabbits: Closed season; no license; unplugged shotgun; possession game and firearms within a refuge	17	950 00	
Shorebirds: Killing shorebirds	1	25 00	
Squirrels: Closed season	1	50 00	
Totals	628	$28,012 70	1,435

SEIZURES OF FISH AND GAME

January, February, March 1950

Fish:	
Abalone	2,823
Black bass	2
Striped bass	111
Striped bass, pounds	20
Catfish	30
Big neck clams	266
Cockle clams	7,730
Gaper clams	81
Pismo clams	2,355
Crappie	18
Crabs	16
Lobsters	501
Mackerel	8
Octopi	20
Octopi, pounds	16
Salmon	8
Sardines	20
Sardines, pounds	1
Sturgeon	1
Sturgeon, pounds	6
Sunfish	30
Trout	51
Game:	
Bear	1
Beaver	1
Deer	36½
Deer meat, pounds	479½
Doves	43
Ducks	368
Elk, pounds	24
Geese	83
Migratory waterfowl	11
Nongame birds	3
Pheasants	57
Quail	28
Rabbits	21
Shorebirds	1
Squirrels	1

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